Kōmanawa Solutions Ltd

Matakanui Gold Limited

Report No: Z24002BOG-2

Bendigo - Ophir Gold Mine Project – Surface Water & Catchment Existing Environment & Effects Assessment

Kōmanawa:

1. ***(verb) spring, well up (of water)***
2. ***(verb) to spring, well up (of thoughts, ideas)***

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Version control

Date	Report no	Issue notes
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29/01/25	Z24002BOG2-Rev1	Substantial additions to effects assessment sections
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15/05/2025	Z24002BOG-2	Report for inclusion in AEE and approval applications
19/08/2025	Z24002BOG-2	Disclaimer adjusted in line with Panel Convener's practice and procedure guidance, July 2025

Authors

Jens Rekker

Principal Hydrogeologist, Kōmanawa Solutions Ltd

Contributors

Mandy Chater, independent hydrologist and hydrographer for Santana Minerals Ltd

Hamish McLauchlan, Chief Geologist, Santana Minerals Ltd

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Executive Summary

This is an assessment of the effects on the flow or volume of surface water and provides key inputs to other experts work including aquatic ecology, wetlands and environmental geochemistry modelling undertaken by others. This assessment concludes the abstraction, diversion, use and return of surface water with the proposed mitigations will result in an acceptable outcome.

The surface water hydrological setting adjoining the proposed Bendigo – Ophir Gold Mine Project (BOGMP) comprises creeks draining the Dunstan Mountains westward into the Lindis River (a tributary of the Clutha) but also the Clutha River / Mata Au main stem *via* Bendigo Creek. The hydrology of Shepherds and Rise and Shine Creeks were previously ungauged but have more recently been characterised by a combination of gaugings and continuous measurement since late 2022. These two years of flow measurement have allowed correlation with surrounding gauged creek catchments draining the Dunstan Mountains. Rainfall measurement has also been instituted at three sites across the BOGMP site.

The mining activities to re-position overburden and extract ore would occur across the Shepherds and Rise and Shine creek catchments. As the mining surface activities extend across the three deposit areas, Rise and Shine (RAS), Come In Time (CIT), and Srex (SRX, plus Srex East pit, SRE), a set of water management perimeters would be established in order to intercept or retain stormwater, other mine-impacted water and shallow groundwater seepage from entering downstream natural water during the operational phase of the mine site. These expanding water management cut-offs would reduce the natural flow rates of Shepherds Creek and, for a briefer period, Rise and Shine Creek (Bendigo catchment), during the operational phase of active mining. Shepherds Creek catchment contains the Tarras Farm Limited Partnership irrigation intake, which diverts up approximately 50% of creek volume out of the creek water course and out of catchment (consent number RM17.301.15).

The operational phase dewatering of the Rise and Shine, Come In Time, and Srex pits at their deepest extent would lead to groundwater depletion of the respective adjoining creeks (Dumont et al., 2025). The Shepherds Creek hard-rock depletion is estimated from MODFLOW modelling to be up to 0.5 to 3.5 litres per second. The Come In Time pit dewatering is estimated from MODFLOW modelling to induce groundwater depletion from Shepherds Creek up to 1.7 litres per second but may also be effectively negligible. Due to higher permeability shallow schist in the Rise and Shine Creek area, Srex pit dewatering is estimated from MODFLOW modelling to induce groundwater depletion from the creek of up to 17 litres per second, extending over a 1¼ year period of operations. But this estimate is likely to be a substantial over-estimate. Surface water would be diverted around the SRX pit and ELF to minimise loss of creek flow during this phase

As RAS pit extends through a short reach of Rise and Shine Creek during the later stages of pit development, it is proposed to construct an extended straddle culvert that crosses the pit wall and redirect creek water back to the creek course downstream of the pit intrusion. The culvert diversion would be sized so as to carry normal flow and lower and maintain continuity to the Bendigo Catchment. However, flood flows from the upstream creek catchment would instead overtop the intake structure and be side-cast into the RAS pit. The loss of high and flood flows from the existing Bendigo catchment into the RAS pit sump would be the sole effect of the diversion besides the short loss of creek course.

Artificial drainage paths would be left in the wake of mining operations into the post-closure period. These altered drainage paths would include:

- Residual pit lakes or backfilled pits that are partially flooded, namely RAS, CIT, and SRX,
- Underground channels, including the RAS pit, flooded underground crown pillar stope and the former access drift that would form the new long-term drainage pathway for the RAS former mining area,
- Drainage of the SRX pit to Rise and Shine Creek by simple overflow at the pour-over point on the pit's edge,

- The already-mentioned creek transfer straddle culvert for Rise and Shine Creek around the southwestern edge of the RAS pit,
- The Shepherds ELF that would sit across the Jean and middle Shepherds Creek catchments and the Western ELF as internally draining masses, and
- CIT backfill and West ELF that would in modest seepage discharges to their respect creek catchments.

The main RAS and SRX surface pits would become partially flooded in the post-closure period. Post closure, RAS pit would maintain drainage through the crown pillar stope void and the former access drift to the surface for water treatment as required and eventual drainage to Shepherds Creek. The pit lake would stabilise at an elevation halfway up the pit wall and an elevation of approximately 490 metres AMSL as a result.

Post-closure alterations to land surfaces of former mining areas following rehabilitation would result in changes to the hydrological function of the affected areas and the mode of surface water runoff. The addition of more permeable and porous materials in affected areas of waste rock and backfilled overburden is projected to lead to a higher proportion of creek flow being made up of base flow at the expense of high creek flows. The former mining area's water balance would also change in terms of the balance of evaporation, evapotranspiration, and infiltration into the substrata. Overall, surface water flows in both arms of the Shepherds and Bendigo catchments would increase. The addition of the RAS pit to the creek network in the post closure phase would include the flow buffering effects of a pit lake and outflow through a cavernous route in former underground workings, which would also result in flow buffering and a higher proportion of creek flow forming base flow. The pit and underground workings outflows would be a mixture of runoff entering the pit lake from the sides and residual seepage inflow from the hard rock groundwater system.

As part of the unique intermontane physiography of the Bendigo area, Shepherds Creek does not extend as a perennial water course to its main stem at the Lindis River. Instead Shepherds Creek is lost to soakage through its bed a full three (3) kilometres short of the Lindis confluence, thereby replenishing the Ardgour Alluvial Aquifer, which in turn seeps into the Lindis River Alluvial Ribbon Aquifer and ultimately the Lindis River. Without treatment this may result in the solutes, including sulphate, becoming elevated by post-closure leaching from ELFs followed by downstream accumulation within the alluvial groundwater system receiving creek infiltration. Conceptual modelling suggests that little *in situ* attenuation in solute concentrations could be expected within the proximal parts of the aquifers. Operational releases of solutes would also occur during storm-punctuated accumulations of rainfall runoff amounting to between 3% and 10% of annual creek flow. These releases of mine-impacted water would carry mass loads of solutes, including sulphate and nitrogen (Mine Waste Management, 2025a). Active water treatment is understood to be proposed to maintain solute concentrations to below proposed compliance limits.

Rise and Shine Creek is a small tributary of Bendigo Creek such that the tributary Mean Annual Low Flow (MALF) is estimated at 1.3 – 5 litres second whereas the Bendigo Creek main stem has an MALF estimated at 33 litres per second. Therefore, the low flow yield of Rise and Shine Creek is in the order of a seventh (7^{th}) of the comparative yield of the larger catchment. Appreciable liberation of operational or post closure solute loads into Rise and Shine Creek are not anticipated from the SRX pit or ELF. Substantial dilution of solute loads in Rise and Shine Creek by larger creeks that do not carry appreciable solute concentrations (Clearwater, Bendigo Left and Right Branches, Perrys, and Aurora) would also be anticipated before creek water entered the Bendigo Aquifer. Mine-impacted water solute concentrations would thus be reduced by factors as much as 7-fold between the Srex mining area and their entry to the Bendigo Aquifer.

In a nutshell, during operations Shepherds Creek would lose perhaps 20% to 30% of previous upper catchment flow contribution and be affected by RAS pit dewatering related groundwater depletion. The proposed diversion of north bank clean water around these impact zones and removal of irrigation abstraction from Shepherds Creek currently below the operations area would remedy or offset these temporary operational catchment losses. SRX pit dewatering would briefly draw off a significant portion of creek flow passing the immediate vicinity of the pit's northwest corner in the latter operational stages of mine life, although

upstream diversions above the SRX pit would preserve the bulk of upper Rise and Shine Creek flows. This creek is in any case a small tributary among much larger Bendigo catchment tributaries. The loss of Rise and Shine flood flows, which could not pass the straddle culvert to the RAS pit sump, would be of low impact. The active closure and post-closure creek network would be significantly restored to their former hydrological function, with the exception of the RAS pit lake and drainage to lower Shepherds Creek through flooded underground workings, altered former ELF and TSF substrates, and the former SRX pit lake. Post-closure catchment hydrology for both Shepherds and Rise and Shine Creeks would be affected by the change in substrates and retention of soil moisture, resulting in higher catchment flow yields and more stable creek flow. Long-term this would be a beneficial outcome for creek hydrology in a water-short part of Otago. Project water supply groundwater pumping would affect the flows of the Clutha River / Mata Au and Lake Dunstan, but in comparison to large available flows and surface water allocation in the main stem, the groundwater depletion effect would be inconsequential.

Overall, the proposal for mining activities in the current location is assessed to have environmental effects in terms of catchment flows, surface water depletion and groundwater resource allocation that are less than minor.

This report relies on the following 2025 reports specifically commissioned for this project:

- Bendigo – Ophir Gold Mine Project – Groundwater Existing Environment & Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Groundwater Modelling Analysis for Bendigo Ophir Gold Deposit ,Kōmanawa Solutions Ltd (KSL).
- Bendigo–Ophir Gold Mine Project – Bendigo Groundwater Bore Take Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Source Term Definition Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.
- Water Load Balance Model Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.

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1 Background

1.1 Outline & Problem Definition

The Bendigo district in New Zealand's South Island is a traditional gold mining area beginning with alluvial mining of terrace gravels from 1862, followed by hard-rock mining of 'quartz reefs' beginning in 1869. Quartz vein mining for gold that extended from 1869 to 1942 tended to exploit cross-cutting quartz veins close to the surface, while trenches and adits were also excavated to intercept these pockets of ore. More recent geological investigation (1985 to 2008), and subsequent prospecting, have had a deeper focus on a mineralised low-angle deformation zone in biotite zone schist in the footwall of the Thompsons Gully Fault. The mineralised rocks within this shear zone are deformed and hydrothermally altered schist. Mineralised zone gold content is associated with pyrite and arsenopyrite scattered through the altered schist but includes free-milling gold.

Matakanui Gold Ltd (MGL, a subsidiary of Santana Minerals) proposes to develop an open cut pit and underground mining complex linked to an ore processing plant in close proximity. In essence, the mining of the newly discovered mode of gold occurrence would involve digging out the ore rock and overburden obscuring the ore, primarily over or to the northeast of the Thompsons Gully Fault (TGF) surface trace. The excavation and underground workings would extend to increasingly greater depths as the mines follow the dipping Rise and Shine Shear Zone (RSSZ) structure. As the depth of the mineralised zone would exceed 250 metres, the economic advantage for open cut mining techniques would be overtaken by the underground option at the Rise and Shine deposit. Deeper mining would therefore be undertaken using underground drives and ore extraction stopes extending from the deepest parts of the open cut pit to the northeast and depths as much as 470 m below the overlying surface. Any overburden would be re-deposited in Engineered Landforms (ELFs), while pulverised ore would be run through the processing plant with tailings deposited as a slurry behind a zoned-earth dam and ELF buttress in the Tailings Storage Facility (TSF). Waste materials of ore originating from the underground mine panels would be deposited as a cemented paste into completed mining panels and the TSF. The processing plant would obtain the bulk of its water supply from mine-impacted water obtained from the Shepherds Silt Pond or the TSF, or as clean water from the bore field installed in the Bendigo Aquifer and Clutha River / Mata Au.

The proposed mining complex comprising open cut pit, underground workings, ore processing plant, engineered landforms of inert waste material, processing tailings, and ancillary water services would all result in some degree of environmental effect. The purpose of this assessment document is to outline the existing surface water hydrological environment and characterise arising surface water environmental effects, including foreshadowing the effectiveness of mitigation, monitoring and offsets / compensation deployed.

1.2 Objectives and Structure

This assessment document stands alongside allied potential environmental effects assessments in other discipline areas, including -

- Mine engineering including the Project Description,
- Groundwater hydrogeology,
- Geochemistry and water quality,
- Geotechnology / Engineering Geology,
- Mine Watse Management,
- Ecology (Terrestrial and Freshwater Aquatic),
- Landscape,
- Noise and vibration,
- Social science,
- Economic,
- Māori Cultural & Spiritual,
- Archaeology and historical, and
- Recreation.

Several of the above discipline areas would dovetail into the assessment of surface water effects arising from the proposed activities. The effects assessments were not developed in isolation, with extensive collaborative assessment approaches having been employed. Where feasible, cross-references to allied disciplines are provided to guide readers to details on the existing environment and cross-cutting potential environmental effects.

The objectives of this document are tailored to provide the information required for assessing effects in terms of the Resource Management Act 1991 and the Fast-track Approvals Act 2024. This information includes more or less the following:

- *A **description of the proposal**,*
- *A description of any **possible alternative locations or methods**, where an activity will result in **significant adverse effects**,*
- *An assessment of **the actual or potential effects on the environment** of the proposed activity;*
- *An assessment of any risks to the environment of an activity which includes the use of **hazardous substances** and installations,*
- *Where an activity includes the discharge of any contaminant, a description of the nature of the discharge, the sensitivity of the receiving environment, and possible alternative methods;*
- *A description of the **mitigation measures** to be undertaken,*
- *Identification of persons interested in or affected by the proposal, **consultation** undertaken if any, and response to the views of those consulted,*
- *How **monitoring** will be carried out if required and by whom, and*
- *Where a protected customary right is likely to be adversely affected by the proposed activity, the AEE must include a description of possible alternative locations or methods for the proposed activity unless written approval is given by the **protected customary rights group**.*

Accordingly, this assessment document focuses on the surface water and hydrology discipline and addressing the above assessments. The final assessments derived from the Assessment of Environment Effects (AEE) process are summarised and links to detailed information provided in accordance with conventional documents of this type.

2 Site Setting & Existing Environment

The Bendigo – Ophir Gold Project (BOGMP) is located in the Bendigo area of New Zealand's South Island, within the local government jurisdiction of Central Otago District Council (see Figure 1). The Bendigo area is located in the Upper Clutha Valley between the urban areas of Wānaka and Cromwell. The Rise and Shine (RAS), Srex (SRX), Srex East (SRE) and Come In Time (CIT) mining areas are located in the middle and upper reaches of the Shepherds Creek or Bendigo Creek catchments on the western slopes of the Dunstan Mountains. A Four-Wheel Drive track from Matakanui locality in the Manuherikia Valley is named the Thompsons Track, which passes through the Rise and Shine Creek valley on Bendigo Station land. The Ardgour Station lies on the north bank of Shepherds Creek, overlooking the proposed RAS and CIT mining areas. Valley floor flats occupied by improved pasture, vineyards and residences are located to the west of proposed mining and processing areas. The underlying Bendigo Aquifer is the proposed source of make-up water supply to the Project. **Error! Reference source not found.** provides an interpretative mapping of the proposed Project area, including proposed open cut pits, ELF, TSF, processing area, plus the water supply bore site in the context of watersheds and geomorphological features.

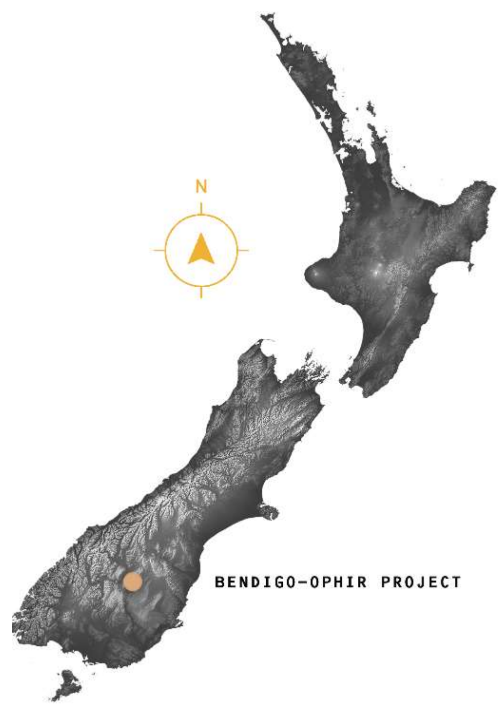

Figure 1: Location of the Project Area in Central Otago, New Zealand

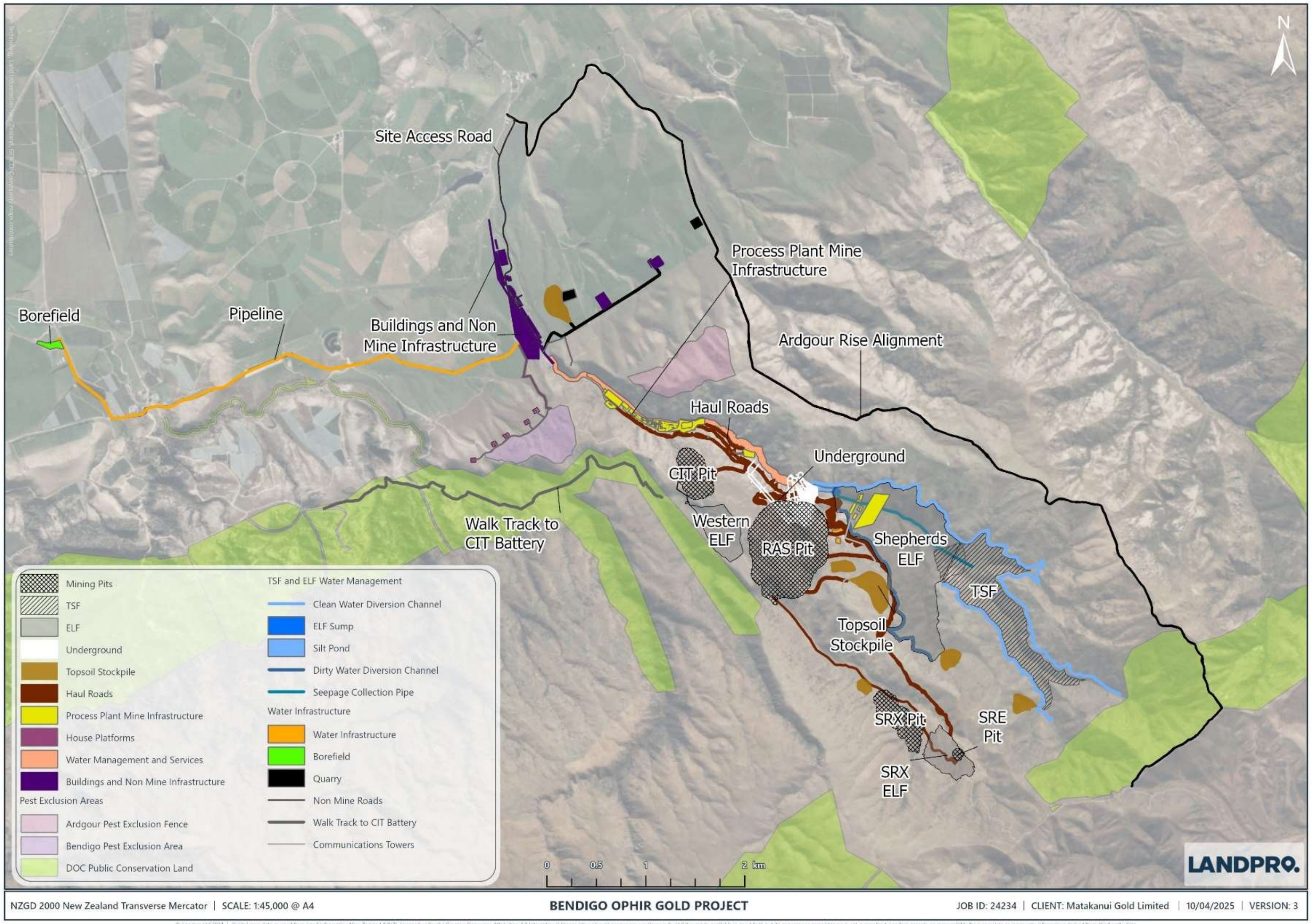

Figure 2: Project Area, including Rise and Shine (RAS), Come In Time (CIT) and Srex (SRX and SRE) deposits

2.1 Location & Communications

Bendigo is accessed from the Cromwell – Tarras Road (State Highway 8), between Cromwell – Lindis Pass and Omarama. Bendigo Loop Road skirts the eastern valley floor from the Lake Dunstan Delta to the lower Lindis River. The Bendigo area may also be accessed from Lake Hawea and Wanaka from the north, via the Luggate – Tarras Road or State Highway 8A. Thomsons Track is a Four Wheel Drive (4WD) route that winds its way through the project area passing the Srex and the Rise and Shine pit areas.

2.2 Geography of Site & Environs

The project area is located broadly within the Shepherds Creek and Rise and Shine Creek valleys on the western flank of the Dunstan Mountains. The locality of Bendigo is a few kilometres to the west. The junction of Lindis Crossing features a bridge across the Lindis River with the intersection of Ardgour Road and the Cromwell – Tarras Road (SH8). The settlement of Tarras lies to the north of the project area, and includes retail outlets, a cluster of houses. and primary school. The Tarras Hall, Fire Station and Golf Club lie further along the State Highway 8.

2.3 Geology

2.3.1 Bedrock

The geological framework of the Bendigo district is based in the Otago Schist bedrock (the geological basement). The schist bedrock has been metamorphosed by regional scale pressure and heat gradients from the nearby Indo-Pacific plate boundary, which causes segregation of some of the main component minerals such as quartz (silica), mica (mostly biotite), or sulphides, in a lithic (general rock) rock mass. These segregated bands are aligned in planes termed foliation. The schist foliation planes imparts a distinct 'grain' to the schist fabric and has been mapped as a structural orientation.

Geologists have differentiated the schist in order to better understand the formation's stratigraphy on the basis of geochemistry and geological fabric. The Otago schist stratigraphy in the Dunstan Range is generally divided as follows –

- Textural Zone 3 (TZ 3), Well foliated, incipiently segregated psammitic and subordinate pelitic schist; minor greenschist and conglomerate; rare marble, or
- Textural Zone 4 (TZ 4), Undifferentiated, well foliated and segregated psammitic and pelitic schist with greenschist and meta-chert bands.

All of the ore-bearing schist is associated with the TZ 4 or the adjacent, overlying Rise and Shine Shear Zone (RSSZ).

2.3.2 Tertiary Sediments

The basement schist has an unconformable contact with the overlying Tertiary sediments, although the sediments are only present in isolated pockets beneath the valley floor.

2.3.3 Quaternary Glacial and Post-Glacial Sediments

The Bendigo – Tarras district has a pattern of glacial outwash remnant terraces and deposition surfaces from glacial outwash phases ranging in age and elevation. The valley floor river terraces and flats are stepped sequence of the following outwash surfaces -

- Alberttown (71,000 – 59,000 years BP),
- Hāwea (17,000 – 12,000 years BP) outwash, and
- Holocene (14,000 years – Present).

The river outwash terraces are tiered from the east to the west and towards the Clutha River / Mata Au. Pleistocene deposits of slender thickness and extent are found on the Dunstan Ranges, including creek alluvium in the Rise and Shine gully, outwash remnants, and landslide deposits in the steepest ground of the Shepherds Creek catchment. Rise and Shine Creek alluvials had been subject to significant re-working by alluvial gold mining from 1870s to 1950s that tended to translate the deposits atop the TZ 4 basement into tailings.

2.3.4 Geological Structure

The surface trace of the Thomsons Gorge Fault (TGF) crosses from the Manuherikia River catchment near Thomson Saddle, passes northwest along the floor of Rise and Shine Creek before crossing into the lower Shepherds Creek drainage until becoming covered by late Pleistocene gravel sediments. The TGF separates the TZ 3 and TZ 4 schist structural blocks. Minor faults cutting across the strike of the TGF have a role in enhancing gold mineralisation along the RSSZ, particularly for the CIT and RAS gold deposits (Mackenzie et al., 2006).

2.4 Soils & Drainage

The Bendigo district has contrasting soil types and classes divided by the following distinctions:

- Lowland soils covering alluvium, outwash and till terraces, or
- Upland soils covering Otago Schist of the Dunstan Ranges.

2.4.1 Lowland Soils

2.4.1.1 Riverine alluvium

Swan Loam and Matapihi Loam are formed over schist alluvium and are poorly drained due to high soil-moisture retention. Ripponvale and Manuherikia loams a typic immature semi-arid soils that are by contract well drained. Waenga silt loam is found in geographical association with the other alluvial soils but differs by being shallow and moderately stoney. Finally, the Gees sand is commonly very stoney, well drained and very shallow. In the river terraces and flats adjacent the main stem river and State Highway the Gees sand soils are restricted to the dry bed of Bendigo Creek as it crosses the surface to Lake Dunstan.

2.4.1.2 Till Terraces

The Bendigo Terrace surface is covered with a range of soil classes, all falling into the category of shallow, well drained sands or loams –

- Molyneux shallow, well drained, sand
- Clyde shallow, well drained loam,
- Ardgour shallow, well drained loam,
- Bendigo moderately deep, well drained loam.

These soil types carry on along the face of the Dunstan Range creek catchments, punctuated by ribbons of Waenga soils associated with Shepherds Creek.

2.4.2 Upland Soils

2.4.2.1 Semi-Arid Soils

Well drained soils with moderate fertility limited by rooting depth due to density, stoniness and dryness. The following semi-arid soils are found on the lower slopes of the Dunstan Range -

- Lowburn,
- Clyde,
- Alexandra, and
- Conroy Hill.

2.4.2.2 Pallic Soils

Medium to high fertility with imperfect to poor drainage due to high density and/or presence of pans, which limit rooting. The following Pallic soils are generally found in the middle slopes of the Dunstan Range -

- Arrow,
- Blackstone Hill.

2.4.2.3 Brown Soils

Low natural fertility but with generally good drainage and rooting depth unless acidic or shallow. The following Brown soils are found surrounding the tops and peaks of the Dunstan Range -

- Carrick,
- Obelisk.

2.4.3 Upland Soil Properties

The upland soil classes have formed on schist rock as the parent material. There is a repeated sequence throughout the Upper Clutha and Manuherikia valleys of semi-arid soils on the flanks, pallic soils on the middle slopes and brown soils on the tops that relates to the conditions of formation and environmental conditions of each altitudinal zone. The tops and the peneplain[1] zones of the uplands tend to be most associated with scattered bog and mire wetlands, and the brown soils tend to be acidic and contain more organic material.

The semi-arid soils are the most well drained, without limiting horizons. These soils tend to be in stoney parts of the range with shallow, outcrop dominated land covers. Overall, the low permeability of the underlying schist rock tends to be the more operative factor in upland soil deep drainage, and lateral drainage of moisture can dominate.

2.5 Climate

The following summary is adapted from *The Climate and Weather of Otago* by Greg Macara of NIWA (Macara, 2015). The Otago region is in the latitudes of prevailing westerlies with lighter winds inland compared to the coast. Annual precipitation in Otago typically decreases with distance from the Alps, as spill-over rain declines and a series of rain shadows impose themselves. Inland Otago is the driest region in Otago and the valley floors of the Bendigo – Tarras districts among the driest in Otago. Dry spells of more than two weeks occur frequently in the area. At the same time temperatures are on average lower than over the rest of the country with frosts and snowfalls occurring relatively frequently each autumn – winter – spring period. During summer hot dry conditions exceeding 30˚ are normal during summer and early autumn.

2.5.1 Rainfall

2.5.1.1 Regional Rainfall Sites

The Otago region has a strong gradient in rainfall from the Fiordland / South Westland catchment divide with the Clutha catchment, and eastward into the drier valley floor parts of Central Otago in the Clutha and Taieri catchments. Figure 3 illustrates the general pattern of contoured mean annual rainfall from 1981 to 2010[2], including high rainfall totals in the west, crossing the Main Divide and coalescing to less than 500 mm per annum in the Upper Clutha valley systems. Figure 3 is a national-scale climate representation of long-term mean annual rainfall across the southern South Island as a colour-flood, showing the BOGMP site being in an area between 250 and 750 millimetres annual rainfall.

[1] A regional erosional surface on top of the schist basement postulated by Otago geologists (Landis & Youngson, 1996), currently less favoured as an explanation of the flat-topped block mountains of Otago, but still in common usage among geologist, geomorphologists and soil scientists.

[2] https://niwa.co.nz/climate-and-weather/overview-new-zealands-climate

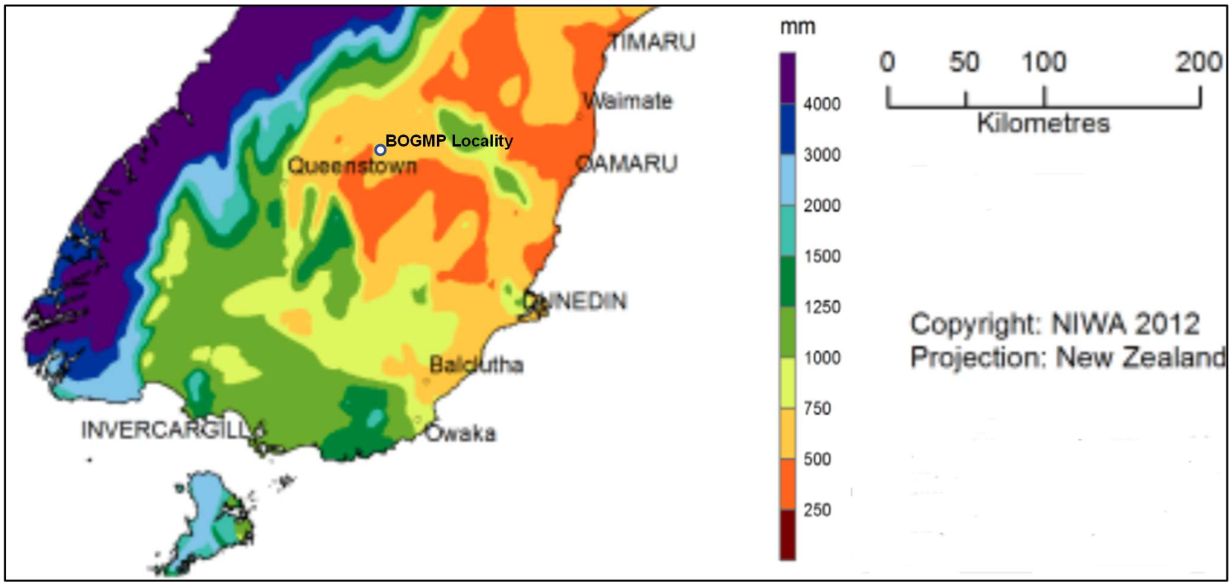

Figure 3: Mean annual rainfall distribution of NZ, 1981 – 2010 centred on Otago

Of the long-term rainfall records of the Upper Clutha, several signature rainfall stations were selected to illustrate long-term statistics and rainfall spatial patterns by comparison. Significant variations in long-term annual rainfall are induced by spill-over rain from the Southern Alps, or rain shadows imposed by the Cardrona, Pisa, and Dunstan mountains. Table 1 lists the rainfall stations of Lake Hawea, Cardrona, Cromwell and Lauder Station (Otago Regional Council (ORC) site) up to the end of the 20th century (Devgun, 1999).

Table 1: Upper Clutha Catchment – Minimum, Mean and Maximum Annual Rainfall Statistics

Rainfall Station		Elevation	Period	Annual Rainfall (mm)		
Site No.	**Name**	**(m AMSL)**	**From - To**	**Minimum**	**Mean**	**Maximum**
F47691	Milford Sound	3	1929-1998	4,243	6,455	9,232
I49621	Lake Hawea	350	1955-1998	530	793	1,156
I49801	Cardrona	518	1927-1998	399	642	943
I59021	Cromwell	213	1949-1998	273	417	617
I59235	Clyde	171	1983-1996	313	444	594
I49972	Lauder Station	549	1987-1998	594	663	823

Source (Devgun, 1999)

The Cromwell climate site is the driest rainfall record and the most representative of the rainfall measured at the project area.

2.5.1.2 Regional Council Rainfall Sites

The closest regional council rainfall record is co-located with the Cluden Stream at Stock Yards flow measurement site located in the lower Cluden Stream floodplain at Easting 1326703 and Northing 5032880, at an estimated altitude of 353 m AMSL. Cluden Stream is a true left bank tributary of the lower Lindis River, draining the western flanks of the Dunstan Range of mountains, characteristics which are in common with Shepherds Creek albeit this creek is further downstream. The Cluden Stream rainfall record is largely complete (less than 0.02% missing data) and measured by bucket tips totalled every hour. The rainfall record began on 25 May 2021 and extends to present, approximately 3.4 years. Lauder Creek at Lauder Basin (sometimes termed "at Cattle yards") is on the eastern flank of the Dunstan Range and at a similar distance to the project area, however the period of record is shorter at 2.7 years from January 2022 to present while also managed for ORC.

2.5.1.3 NIWA Rainfall Sites

The main operational rainfall recording sites with intra-daily rain data in proximity to the project area represented by Lake Clearview are as follow:

- Cromwell, on the edge of the township at elevation 213 m AMSL and a distance of 14 km,
- Lauder, at the NIWA atmospheric research station and elevation 375 m and a distance of 32.2 km.

The Cromwell climate records were merged (EWS and MWD climate recording sites) and used to develop a longer synthetic rainfall records by concurrent correlation of Lake Clearview with Cromwell EWS sites (Chater, 2023).

2.5.1.4 Bendigo Ophir Gold Mine Project Rainfall Sites

Three tipping bucket rain gauges were installed during May 2021 and managed by Santana Minerals, at the following sites:

- **Lake Clearview**, an artificial water storage pond on the Bendigo Terrace, with a meteorological site,
- **Come In Time**, a meteorological site set up on the edge of the proposed CIT pit,
- **Srex**, a meteorological site set up on the edge of the proposed main SRX pit

Table 2 summarises the three BOGMP rainfall measuring sites with a record to date totalling 2.12 years of data, including the site elevation and measured 2-year mean annual rainfall.

Table 2: Summary annual rainfall for the BOGMP measuring sites in the two years, November 2022 to Jan 2025

Site	Period	Elevation (m AMSL)	Mean Annual Rainfall (mm)
Lake Clearview	21 Nov 22 – 3 Jan 2025	340	441.8
Come In Time	21 Nov 22 – 3 Jan 2025	475	465.8
Srex	21 Nov 22 – 4 Jan 2025	753	506.8

Specific Rainfall Events with Corresponding Runoff

Several periods of higher intensity rainfall occurred in the above BOGMP rainfall record. Notable among these was a rainfall sequence from midday 2 October to midday 3 October, 2024with a tail of rain until the morning of 4 October 2024. Figure 4 displays the dual cumulative rainfall curves for the three BOGP rainfall gauges and corresponding flow rate measured at the Shepherds Creek flow gauge (SC-01), which has an upstream catchment of 11.98 square kilometres.

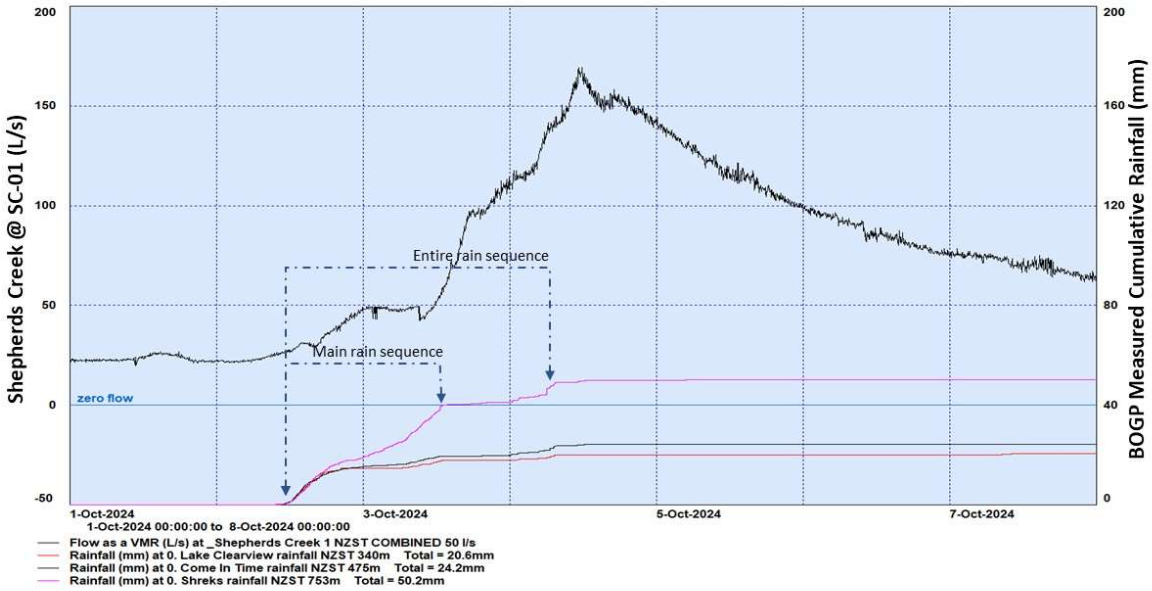

Figure 4: Cumulative rainfall and Shepherd Creek flow rate from base to peak flow, 2 – 5 October 2024

The rainfall event accumulates approximately 18 mm at the lower altitude sites of Lake Clearview and Come In Time for the main rain sequence. The rainfall total measured at Srex at the close of the main rainfall sequence was approximately 40 mm. The entire sequence rainfall totals for Lake Clearview, Come In Time and Srex were measured at 20.6 mm, 24.2 mm, and 50.2 mm, respectively. Creek flow rate response lagged the main and total rainfall sequence by a considerable amount. The peak flow rate of approximately 170 litres per second was measured at midday 4 October 2024, a full 2 days after the start of heavy rainfall on 2 October 2024.

The 2 – 5 October 2024 rainfall event illustrated two main aspects of rainfall – runoff dynamics in the project area:

- The larger part of the rain fell in the upper catchment to the east of the project area,
- There was a positive rainfall – topographic relationship or gradient between the three rain gauges across the main ridge from west to east and 340 metres to 763 metres of elevation,
- The melting of snow and ice in the Shepherds Creek headwater may have been a factor in initiating runoff, and
- Runoff building in the upstream creek catchment took hours, and potentially days, to produce peak creek flow rate(s), however the dual peaks in the rainfall may have obscured the relationship.

Following the peak flow rate in the wake of the 2 – 5 October rain event a conventional flow recession curve transitions creek flow from flow conditions back to base flow conditions. Figure 4 displays the slope of the recession curve from 170 to 85 L/s over 3½ days. Base flow conditions could be approximate as flow rates of around25 litres per second, measured prior to the onset of rain in Figure 4, above.

An earlier rainfall downpour was more concentrated along the western faces of the Dunstan Range resulting in higher rainfall rates measured at Lake Clearwater than the higher altitude rain gauges at Come In Time and Srex. This rainfall event was a shorter, sharper rain sequence beginning at midday 21 September 2023 until midday the next day. Peak rainfall intensity at Lake Clearview gauge was 9.2 millimetres per hour. The base flow in the preceding period averaged 17 litres per second at the flow gauge (SC-01) on Shepherds Creek. Following the 24 hour rainfall sequence, Shepherds Creek flow rate peaked at 145 litres per second before progressing into a flow recession.

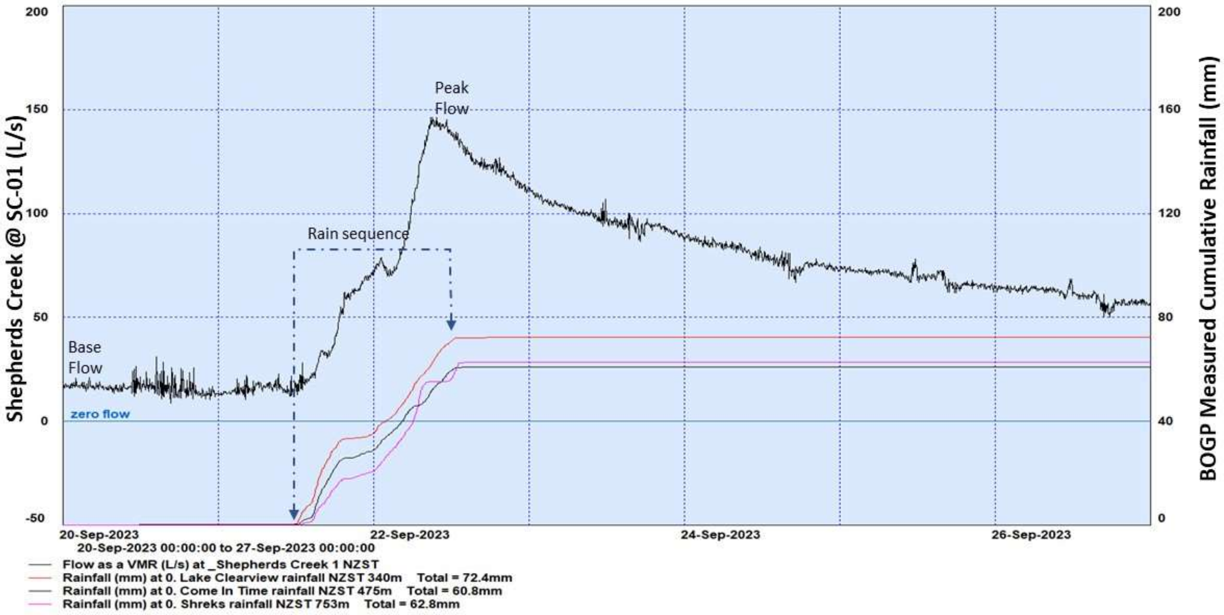

Figure 5: Cumulative rainfall and Shepherd Creek flow rate from base to peak flow, 21 -22 September 2023

The advantage of analysing the 21 – 22 September 2023 rainfall sequence was the relative uniformity of rainfall across the three rain gauges at the time of the event, averaging a 24-hour rainfall of 65 millimetres at each of the three BOGMP rain gauges. Creek flow at the SC-01 monitoring site peaked at or shortly after the conclusion of the 24 hour long rainfall event. The rain event will have sustained elevated creek flow until the base flow condition once more prevailed.

Development of Long-Term Synthetic Rainfall Record

The principal obstacle to obtaining a long-term representation with relevant rainfall statistics was the limited rainfall records for the project area. To extend the application of these sites to the wider rainfall record, the Cromwell combined sites back to 2006 were used to develop a synthetic rainfall record for Lake Clearview. An analysis and correlation to extend Cromwell rainfall data to Lake Clearview used a synthetic rainfall developed from consecutive pieces of the 75-year rainfall record measured at the three Cromwell sites (Cromwell EWS, Cromwell 2, and Cromwell MWD). A relationship with the wind direction of rain storms was noted. However, in the final analysis the correlation between Cromwell rainfall records and Lake Clearview utilised all available rainfall data. An overall corelation R^2 coefficient of 0.84 was derived from the cross-plotting of Lake Clearview and Cromwell EWS rainfall data with two anomalous down-pours removed. This approach recognised that pre-2006 modelled synthetic rainfall was less accurate on a day to day basis.

The synthetic cumulative rainfall plot is illustrated in Figure 6. It covers the period 1949 to 2024 on the basis of the composite correlation synthesis with Lake Clearview at Bendigo and three consecutive rainfall records at Cromwell. The purpose for developing the synthetic rainfall record was to provide a basis for generating representative rainfall statistics of the project area anchored on the Lake Clearview rainfall station.

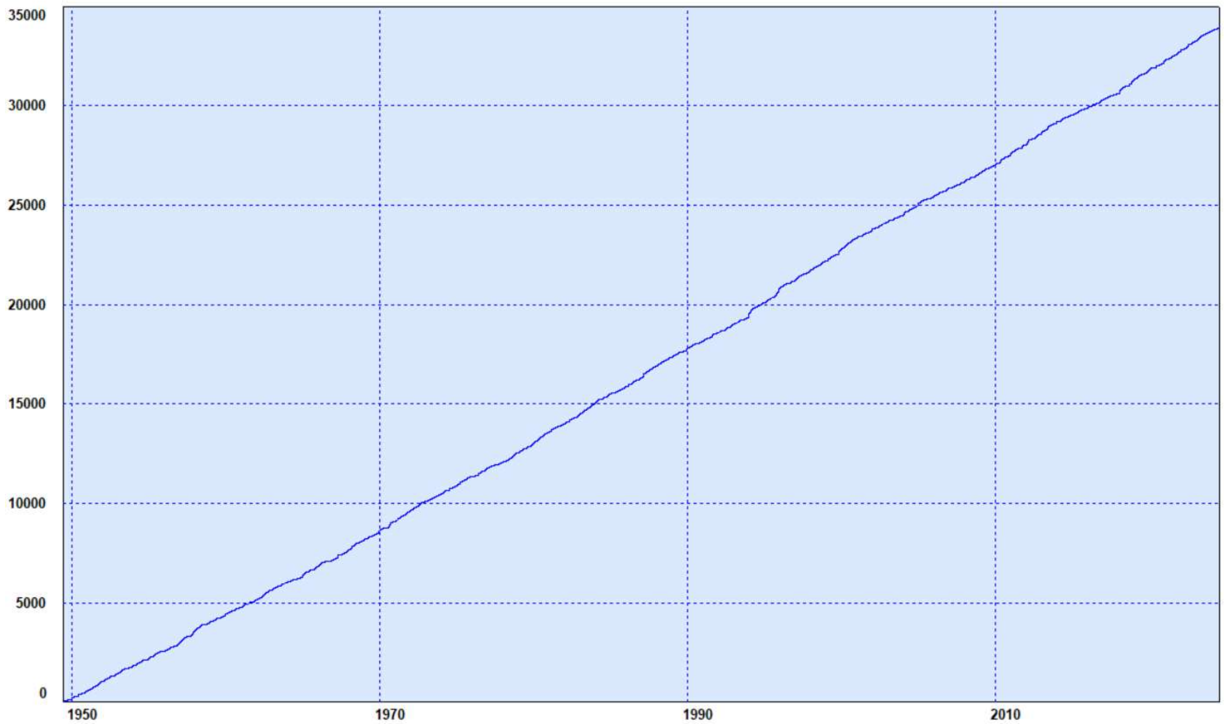

Figure 6: Cumulative synthetic simulation plot of Lake Clearview rainfall from the three Cromwell sites[3]

Table 3: Synthetic mean annual rainfall at Lake Clearview, and other BOGMP sites

Site	Period	Elevation (m AMSL)	Mean Annual Rainfall (mm)
Lake Clearview (Synthetic modelled)	3 Jun 1949 – 1 Aug 2024 (75.1 years)	340	*451.5*
Come In Time (Synthetic, correlated)		475	*464*
Srex (Synthetic, correlated)		753	*507*

The predicted (synthetic) rainfall would differ across the three measuring sites, and indeed across the project area. Table 2 with the displayed rising mean annual rainfall with rising site elevation and implies a positive topographic gradient of +0.16 millimetres per metre of elevation with a high regression correlation coefficient (0.99). This allowed the estimation of the synthetic long-term rainfall mean to be correlated for the other BOGMP sites for estimation of corresponding Come In Time and Srex mean annual rainfalls in Table 3.

The annual rainfall total variation for the 73 hydrological years from 1950 to 2023 is shown in Figure 7. The extremes of annual rainfall range from about 300 mm (1976) to 695 mm (1984). The rainfall at Lake Clearview is therefore slightly higher than the driest parts of New Zealand with mean annual rainfalls less than 400 mm, such as the Alexandra basin, Maniototo, or parts of the upper Waitaki / Mackenzie basin.

[3] Cromwell EWS (April 2006 – Present), Cromwell 2 (July 1984 – April 2006), and Cromwell MWD (June 1949 – July 1984)

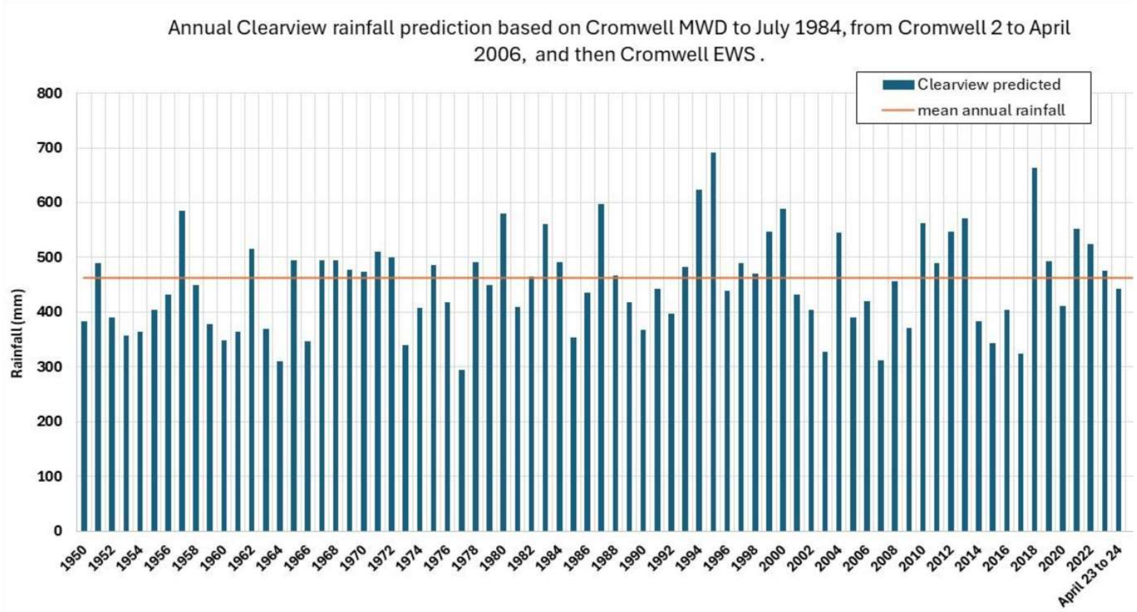

Figure 7: Predicted (synthetic) plot of annual rainfall at Lake Clearview, 1950 – 2023 hydrological years

2.5.1.5 Cliflo Daily Rainfall Sites

Proximal daily rainfall totals were recorded in two locations (currently closed) over the Bendigo Aquifer adjacent to State Highway 6 between Lindis Crossing and Crippletown.

- Bendigo 1 (Crippletown, agent no. 5242) from 1/01/1956 to 30/06/1979,
- Bendigo 2 (Lindis Crossing, agent no. 5243) from 1/05/1978 to 31/05/1992.

In addition, Tarras and Matakanui have records stretching into the present. Figure 8 plots the BOGMP meteorological sites alongside more distant NIWA and Cliflo rainfall recording sites.

Figure 8: BOGMP meteorological sites (blue) and historical rainfall recording sites (red), with elevations

2.6 Surface Hydrology & Water Resources

In terms of the National Policy Statements (FM) 2014 - 2020 and the declaration of Freshwater Management Units (FMU), ORC has determined that the Bendigo district rests within the Dunstan Rohe of the Clutha FMU. The Upper Clutha is sustained by the catchment outflow of Lake Wānaka and Lake Hāwea, which belong to the Upper Clutha Lakes Rohe.

These glacial lakes are a significant source of water for the downstream Clutha / Mata Au river system and remaining water resources in the whole Clutha system. For illustrative purposes, the Lake Roxburgh river inflows were found by water balance studies to comprise 83% flow contribution from the three upstream glacial lakes (Hāwea, Wānaka and Whakatipu) with only 17% flow contribution of the intervening catchment (e.g., Cardrona, Lindis, Shotover, Nevis, Fraser and Manuherikia).

The intervening, smaller catchments are more dominated by lower rainfall zones. The Southern Alps forming the Main Divide with the West Coast are a belt of mountains with unusually high precipitation rates (snow, fog deposition, hail and rainfall) up to 10,000 mm/year. The glacial lakes have substantial live storage (especially the artificially managed Lake Hāwea) and collect the runoff from the Harris, Huxley, Young and Cardrona mountain ranges, plus the Southern Alps' main divide and outrider ranges.

The principal water uses in the lakes' catchments are primarily non-consumptive, such as the disparate industries of hydroelectricity and snow making for ski areas. Town and community water supply is the next most common utilisation of water from lakes and groundwater. Irrigation in the Cardrona Valley and Hāwea Flats from surface water takes and groundwater is a locally significant use of water for improved pasture in these valley floor areas lying within partial rain shadows.

The two glacial lakes, Wānaka and Hāwea feeding the Upper Clutha River / Mata Au, pass on approximately 260 cubic metres per second (260,860 L/s) on average to the downstream river system *via* the Hāwea and Upper Clutha / Mata Au rivers, representing more than 42% of the river system's total discharge at the Pacific coast near Balclutha. The mean outflows from the lakes also equate to a combined specific discharge of 66 litres per second per square kilometre (L/s/km^2) of upstream lake catchment, six times more than the specific discharge of the tributary Lindis River at Lindis Peak of only 11.2 L/s/km^2.

This disparity in specific runoffs is indicative of the spill-over precipitation characteristic of the Aspiring segment of the Southern Alps feeding the lake tributaries, combined with reduction in precipitation by rain shadowing of Grandview and other ranges, lowering the rates of precipitation to the upper Lindis catchment. The same pattern is evident in the rain-shadowed valley floors and tectonic basins throughout northern Central Otago (see Figure 3). Estimates of mean, median and 7-day Mean Annual Low Flow ($MALF_{7d}$) made using measurement site data up to 2014-17 and provided by Contact Energy Ltd are included in Table 4.

Table 4: Summary of Flow Statistics for Upper Clutha Lakes (Wānaka & Hāwea) entering the Upper Clutha

	NZ Segment #	Area (km^2)	Start of Record*	No. of years	Mean (L/s)	Median (L/s)	$MALF_{7d}$ (L/s)
Lake Wanaka at Roys Bay	14196259	2,564	Feb. 1933	84	198,482	177,327	81,300
Lake Hawea at Dam	14192731	1,281	Jan. 1933	81	62,376	58,763	29,900

Note: No. of years = Number of years of flow record. * Selected record for Lake Wanaka ended on 12 July 2017, and Lake Hawea ended on 9 April 2014. However, these sites are in continuous operation to present.

Downstream of the lake outlets, the Cardona River, Luggate Creek, Crook Burn and Lindis River tributaries join the flow of the Upper Clutha main stem, which collectively may increase the main stem mean flow by another 10,150 L/s before the river reaches the Bendigo district. Combined, the Upper Clutha flowing past the Bendigo area and entering Lake Dunstan has a mean flow of approximately 271,100 litres per second (L/s). For comparison, the Clutha at Lowburn flow monitoring site that commenced in November 1967 and ceased operating in January 1992 following the filling of Lake Dunstan, recorded a period-normalised mean flow rate of 271,000 L/s (Devgun, 1999). Lake Dunstan, which was filled behind the Clyde Dam to an elevation of about 194 metres AMSL and reaching upstream to Bendigo Delta, has a combined inflow of 494,000 litres per second based on a normalised catchment water balance (Devgun, 1999). This artificial lake catchment includes the Whakatipu, Shotover, Arrow, Nevis, Roaring Meg, and Long Gully sub-catchments carried by the Kawarau River that combines with the Upper Clutha River / Mata Au at Cromwell.

Generally speaking, the development of water resources beginning in the late 19th century had concentrated on tributaries using contouring water races to divert flow and deliver surface water to pastures by gravity for wild flood methods of irrigation. In the last 30 years the emphasis has changed to pumped abstraction from the main stem to provide greater quantities of irrigation water. The dispatchable hydroelectric storage at Lake Hāwea is significant to the downstream Clutha power stations, as are the other natural flows from the rest of the Upper Clutha Lakes catchments.

2.7 Groundwater & Associated Water Resources

Groundwater in the Bendigo district has two overarching domains –

- Saturated consolidated rocks such as schist basement, or
- Alluvium or outwash sediments, generally coarse sandy gravels.

Alluvium and voluminous outwash gravel deposits are concentrated within the valley systems such as the Lindis Valley and Upper Clutha Valley. As detailed in the next sections, the alluvium and outwash gravel deposits have high permeability and porosity, allowing the conveyance of copious quantities of groundwater through the deposits. Defined areas of such groundwater resources within the Bendigo area can be summarised as follow:

1. Bendigo Aquifer, glacial outwash of the Alberttown and Hawea glacial periods, plus Holocene Clutha alluvium,
2. Lindis Alluvial Ribbon Aquifer (LARA), Holocene river alluvium associated with the lower Lindis River, and
3. Ardgour Alluvial Aquifer (AAA), Alberttown glacial period outwash located between the LARA and schist basement in the Lindis Valley,

These aquifers are recognised by ORC as aquifers and groundwater resource management zones. The LARA is mentioned in regional water policy so that water takes from wells, bores or galleries are managed as though the abstraction were surface water from the Lindis River, including the planned new gallery-based irrigation abstraction systems for the Lindis River under Plan Change 5A and long-term resource consents. Groundwater and associated water resources (e.g., stored soil moisture, creek or river hyporheic zone) are important reservoirs buffering the depletion of flow rate in recessions to base flow periods between accumulations of rainfall.

2.8 Water Resource Infrastructure in Wider District

2.8.1 History of Water Races

Water use in the district began as water races to be used in hydraulic sluicing of gold-bearing gravel terraces around Logantown and the Bendigo Creek catchment. While the Lindis River and Tarras Creek catchments were largely barren in terms of gold, graziers eventually adopted the use of water races diverting water from the Lindis River, Lindis tributaries such as Shepherds Creek, and Bendigo Creek to pastures. Wild flood irrigation was the ubiquitous method of irrigating pastures. Later in the 20th Century, constructed and graded border dyke fields were developed over parts of the district using the same race water, notably at Ardgour. Currently, water race diversions and direct pump intakes on the Lindis River deliver irrigation to most of the lower Lindis River and Tarras Creek catchments. Water races were directed across catchment divides, including the Jolly's water race feeding the Tarras township pastures in the Tarras Creek catchment, or the now disused Begg - Stacpoole water race to Bendigo. These races conveyed Lindis River water slightly outside of the Lindis catchment to surrounding terraces.

From the mid-1800s until 1967 water authorisations were issued by the Miners Warden Court in either Cromwell or Pembroke (Wānaka). These authorisations under the Mining Act have been termed miners' rights, mining privileges, or deemed permits (from 1991 to 2021) and included attached water race easements. Another aspect of the deemed permits grandfathered from the Mining Act 1924 into the Resource Management Act (RMA) in 1991 was immunity from normal water resource controls such as minimum river flow limits. The holder of the oldest mining privilege also held seniority or priority over younger rights. Mining privileges that still exist in the Lindis catchment have been carried beyond the intended expiry on 1 October 2021. The deemed permit and water races permits for the main irrigation take from Bendigo Creek were surrendered and converted to a conventional RMA water permit (Consent No. RM20.079.01) in July 2021, prior to the expiry of the privilege later in October that year.

2.8.2 Contemporary Water Uses

Water races for irrigation continue in use, although several have fallen into disuse including the Begg - Stacpoole. The Lindis Race Company intake near Archies Flat, the Thompsons (Ardgour) Race and Jolly's Race from the Lindis River main stem are still in use. Even the remaining large water races listed above are said by their operators to be reaching the end of their useful life. Changes to national and regional water policy in the 2010's drove the need to re-evaluate the irrigation headworks and ability to operate within minimum flow rules. In accordance with the Plan Change number 5A (Lindis: Integrated water management) under the Otago Regional Plan: Water, these water races are to be replaced by large infiltration galleries to be installed in the flood plain alluvium of the lower Lindis River. The timing of this transition is currently difficult to estimate due to regulatory uncertainty and the lead time required to undertake the shift to infiltration gallery intakes. Dozens of Lindis River tributaries, including Shepherds Creek, are diverted into races and pipelines for transfer and application at pastures, also in some cases for stock water or hydroelectricity generation.

The legacy in Otago of the Mining Act authorisations to water includes a raft of short-term water take consents expiring in 2026 embodying all of the mining privileges that had not been converted to RMA consent by April 2021. In the Bendigo district many if not all of the mining privileges have been converted to RMA authorisations already, including takes in most of the Lindis River and Tarras Creek catchments, plus Bendigo Creek.

In the meantime, a substantial shift and expansion to the sources of irrigation water has been underway with the establishment of large water bore clusters on the banks of the Clutha River / Mata Au downstream of Māori Point. Initially, these irrigation bore developments provided water for terrace top pastures that had never previously been irrigated, such as The Bend Terrace. Subsequently, the 2010's saw multiple bore fields and the installation of HPDE buried pipelines from the Clutha River / Mata Au margin to pastures throughout the Bendigo and Tarras districts.

The use of Shepherds Creek and Bendigo Creek have also been undergoing change from water races to pipelines and storage dams for greater flexibility and efficiency of water use. Shepherds Creek is taken at a single point for the Tarras Farm Ltd Partnership, run through an HPDE pipeline and collected in a 3.1 ha, lined reservoir before being pumped to surrounding pivot irrigators.

Bendigo Creek water is taken by Bendigo Station Ltd in the middle reaches of the catchment using a flooded siphon. Up to 50 L/s is diverted *via* the siphon and pipeline to a storage pond on the Bendigo Terrace where it can be mixed with bore water from the Bendigo Aquifer and used in pasture or horticultural irrigation. Both

Shepherds Creek and Bendigo Creek waters are likely to be fully allocated in singular resource consents to their respective consented uses.

Large capacity water bores at diameters from 300 to 400 millimetres have also spread across the Bendigo Aquifer surface to service changes in land use from extensive sheep farming to a range of more intensive sheep and beef, dairy support, horticultural and viticultural water uses. More than 30 irrigation bores have been established and attached to water take consents across the aquifer. In recent years, it has become recognised that the cumulative effect of irrigation bores that are sufficiently close to the Clutha River / Mata Au to induce a theoretical 533 L/s by surface water depletion. Up to 17.4 million cubic metres of groundwater per annum is allocated from the Bendigo Aquifer, much of it also inducing subsurface augmentation from the Clutha River / Mata Au. The aquifer is also relied upon for domestic, stock and frost-fighting at lower rates of abstraction from smaller diameter bores under various lawful water use authorisations.

3 Hydrological Investigations and Findings

Targeted investigation of hydrological and related matters were undertaken as part of the BOGMP. These may be summarised as follows –

- Establishment of rainfall measurement sites at three locations across the project area,
- Establishment of automated flow measurement sites at the principal creek drainages across the project area,
- Progressive data review and physical updates to the rainfall and flow measurement instruments.

3.1 Bendigo Ophir Gold Mine Project Hydrological Sites

The summary details on the BOGMP hydrological flow sites are listed in Table 5. The location of these sites, plus the creek and groundwater quality monitoring sites, are shown in Figure 9.

Table 5: Summary of Bendigo – Ophir Gold Mine Project hydrological flow monitoring sites

	Easting (NZTM)	Northing (NZTM)	Start Date	End Date at download	Catchment Area (km^2)	No. of Years	Elevation (m AMSL)
Shepherds Creek, **SC-01**	1315697	5019155	15/12/2022	31/01/2025	11.976	2.1	388.2 (d/s)
Shepherds Creek, **SC-03**	1319246	5017638	15/12/2022	31/01/2025	6.368	2.1	579.8 (u/s)
Jean Creek, **JC-01**	1319122	5017651	14/07/2023	17/01/2025	1.407	2.09	579
Rise & Shine Creek, **RS-01**	1317713	5016973	15/12/2022	31/01/2025	4.710	2.1	711 (d/s)
Rise & Shine Creek, **RS-02**	1318918	5016027	15/12/2022	31/01/2025	2.864	2.1	759 (u/s)

Note: u/s mean Upstream of the Downstream (d/s) flow measurement site.

3.1.1 Shepherds Creek

Shepherds Creek drains the western flank of the Dunstan Mountains and rests within the Lindis River catchment. The creek has a 11.5 square kilometre catchment area upstream of the SC-01 flow gauging and monitoring site, while the creek begins to steadily lose water flow downstream of this point in response to increasing creek bed permeability. The creek routinely loses flow entirely at a point 3.5 kilometres further downstream that coincides with the upgradient edge of the Ardgour Alluvial Aquifer. The creek may extend in a flowing state from headwaters to the Lindis River only as a result of periods of exceptionally high rainfall and flooding. The creek in the middle and lower reaches is therefore intermittent to ephemeral. The creek to the normal limit of flow has a vertical fall of 504 metres and mean bed gradient of 0.053 metres per metre (1 in 19). Shepherds Creek passes from an alpine zone to a dry valley floor physiographic zone through a series of bedrock gorges.

Shepherds Creek was not a gauged catchment until December 2022. The closest temporary regional council gauged creek in similar physiographic position is another Lindis River tributary named Wainui Creek, South Branch @ Hut, lying 7 kilometres to the northeast with a flow record from 15 November 2012 to 12 March 2016. A private flow recording site for consent compliance is operated by Bendigo Station on Bendigo Creek at a point approximately 2 kilometres to the southwest of Shepherds Creek, SC-01. A permanent regional council hydrological site is located on the Lindis River as Lindis River @ Ardgour Road, approximately 6 kilometres to the northwest of SC-01 and downstream of the notional Shepherds Creek confluence with the Lindis River main stem.

Hydrological site SC-01 is the main Shepherds Creek measurement site, including a high flow flume. The combination of sites SC-03 and JC-01 measures the flow rate of the middle - upper reaches of Shepherds Creek. The hydrograph of SC-01 and its full 1.93 year record is plotted in Figure 10. The largest data gap is 33.9 days (2-May-2024 to 5-Jun-2024). The flow record is 92.6% complete. From 5 June 2024 the flow monitoring site was equipped with an expanded weir that proved more accurate in measuring higher flow rates. As a result corrections were made to the rating curve for calculation of measured flow rate when the apparent flow rate exceeded 50 litres per second. Figure 10 includes two differently coloured hydrographs; black hydrograph for flow measurements before 5 June 2024, and red hydrograph after that date reflects the adjusted high flow corrections.

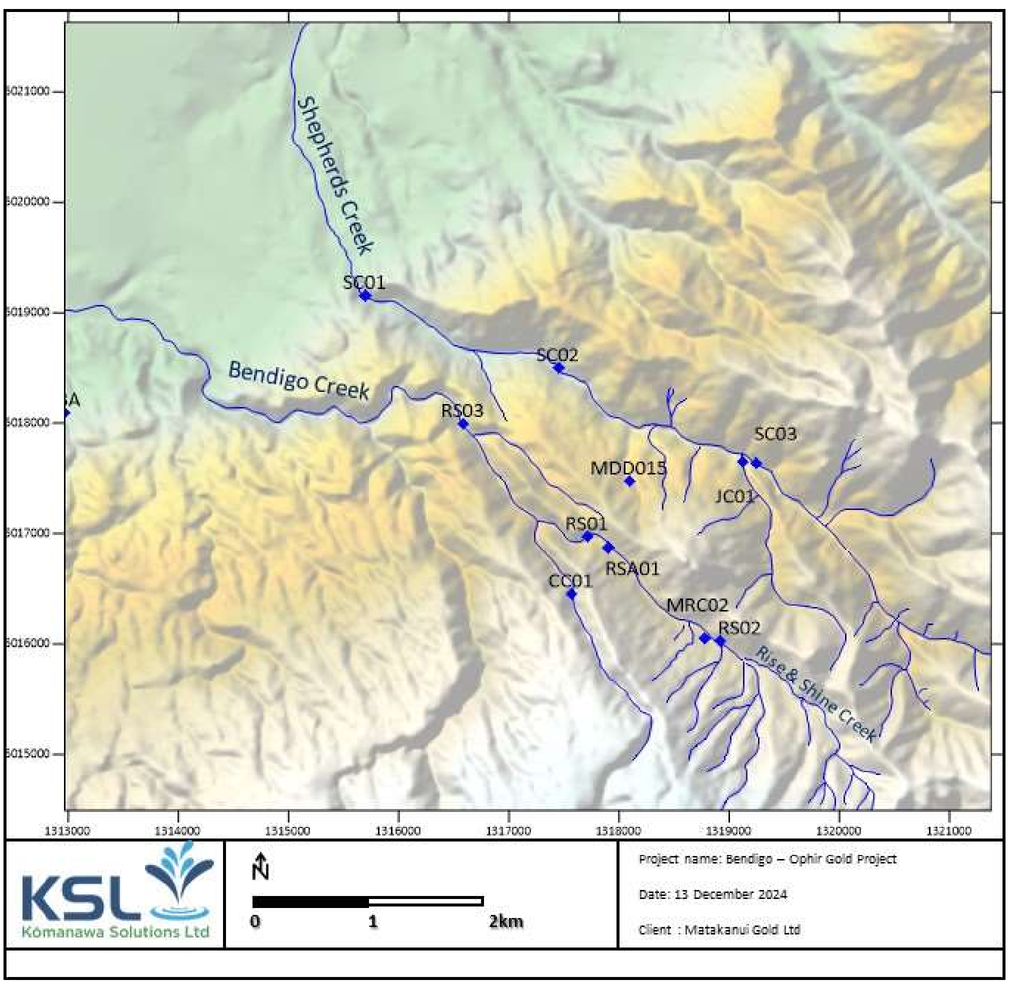

Figure 9: Baseline water monitoring sites, including SC-01, SC-03, RS-01, RS-02 & JC-01 flow monitoring sites

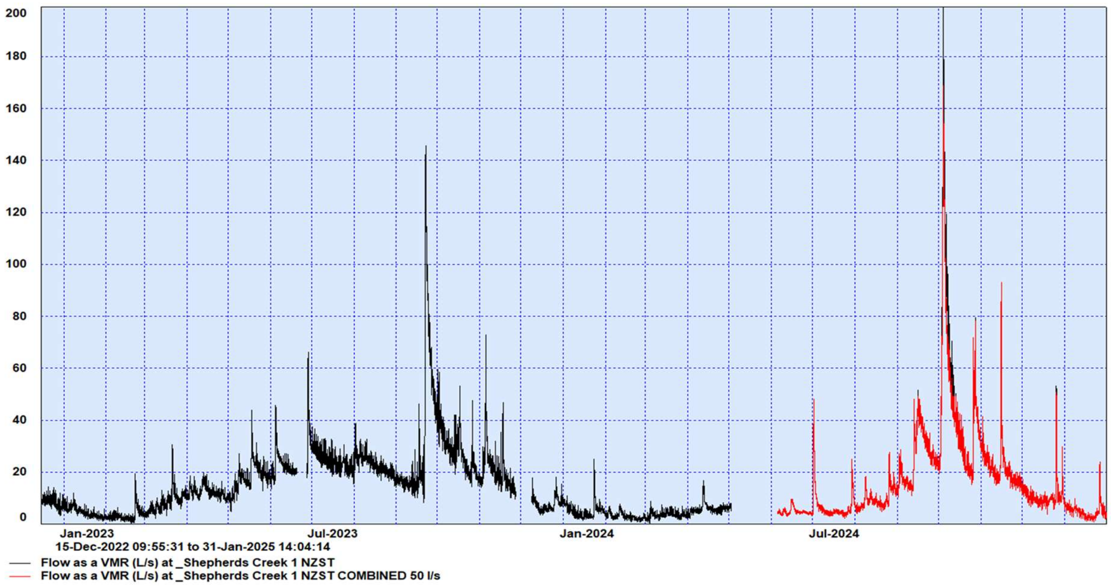

Figure 10: Shepherds Creek @ SC-01 certified flow hydrograph (15 Dec 2022 – 31 Jan 2025)

Shepherds Creek has a defined hydrology from the above 2 year measured flow period as follows in Table 6. Recognising that the measured flow record is relatively brief, opportunities for correlation with adjoining catchment were assessed. Therefore, modelled flow over a longer period of 12 years is included in Table 6 using synthesis of the hydrograph as outlined in section 3.2.2.1. This approach used the recorded flow record of Cluden Stream at Stockyards and correlation between it and Shepherds Creek @ SC-01.

Table 6: Hydrological statistics of Shepherds Creek SC-01 site as measured and modelled flow rate

Parameter	As Measured	As Modelled
Measured data duration (yr)	**1.93** (15 Dec 22 – 29 Nov 24)	**12** (23 Nov 12 – 29 Nov 24)
Number of Hydrological seasons, Complete (yr)	1	11
Number of Hydrological seasons, All (yr)	2	12
Minimum flow, lowest daily mean flow (L/s)	2.1	0
Maximum flow, highest daily mean flow (L/s)	141.4	356.3
Mean flow (L/s)	15.6	18.6
Median flow (L/s)	11.7	12.5
$MALF_{7d}$, Complete (L/s)	2.51	4.25
$MALF_{7d}$, Entire Recorded Seasons (L/s)	2.48	4.24

The modelled flow statistics with source data spanning 12 years would hold more validity as the modelled flow record would encompass a substantially longer sample of climate-driven variation. A flow record of 2 years is manifestly inadequate for use in water resource assessment[4], while 12 years would be more acceptable, albeit

[4] "A 'good' record length is considered to be at least ten years and preferably twenty, with more being desirable in some parts of New Zealand where decadal influences on climate and river flow have been observed"(Henderson & Diettrich, 2007).

the source of data was modelled by correlation with another catchment rather than measured. Figure 11 plots the flow duration curve referencing the modelled flow record for Shepherds Creek @ the SC-01 hydrological site using 24-hour mean flow rates.

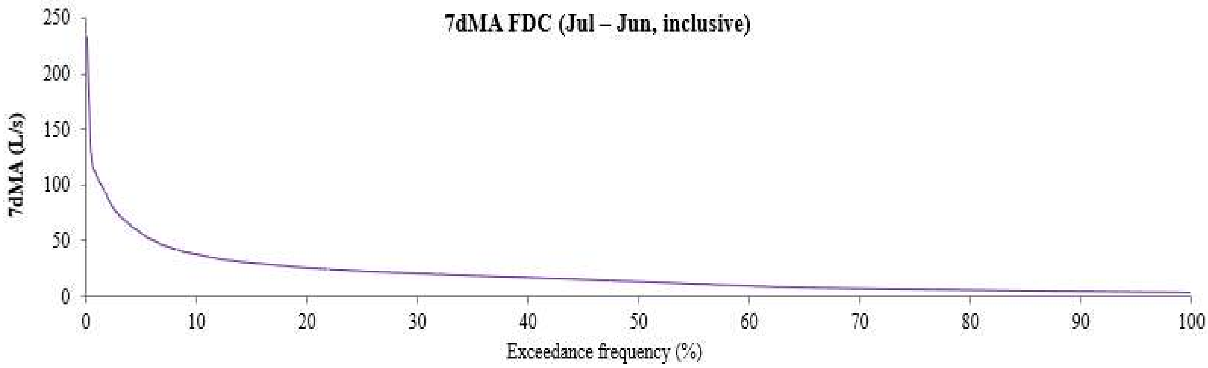

Figure 11 Shepherds Creek modelled 7-day Mean Annual Flow Duration Curve (7dMA FDC) 2012 – 2024

The remaining hydrological flow sites in the Shepherds Creek catchment are Shepherds Creek @ SC-03 and Jean Creek at JC-01. These sites are adjacent to each other with SC-03 immediately upstream of the Jean Creek confluence. Site JC-01 was located immediately upstream of the creek confluence. Hence the combined flow of the two flow monitoring sites defines the total flow of the upper creek headwaters.

Shepherds Creek at SC-03 with its 6.37 square kilometre upstream catchment maintained a positive flow value (minimum of 1.4 L/s) on an hourly basis throughout the 2 year flow record. The hydrograph is plotted in Figure 12. The largest data gap is 33.8 days (2-May-2024 to 5-Jun-2024). The flow record is 92.5% complete.

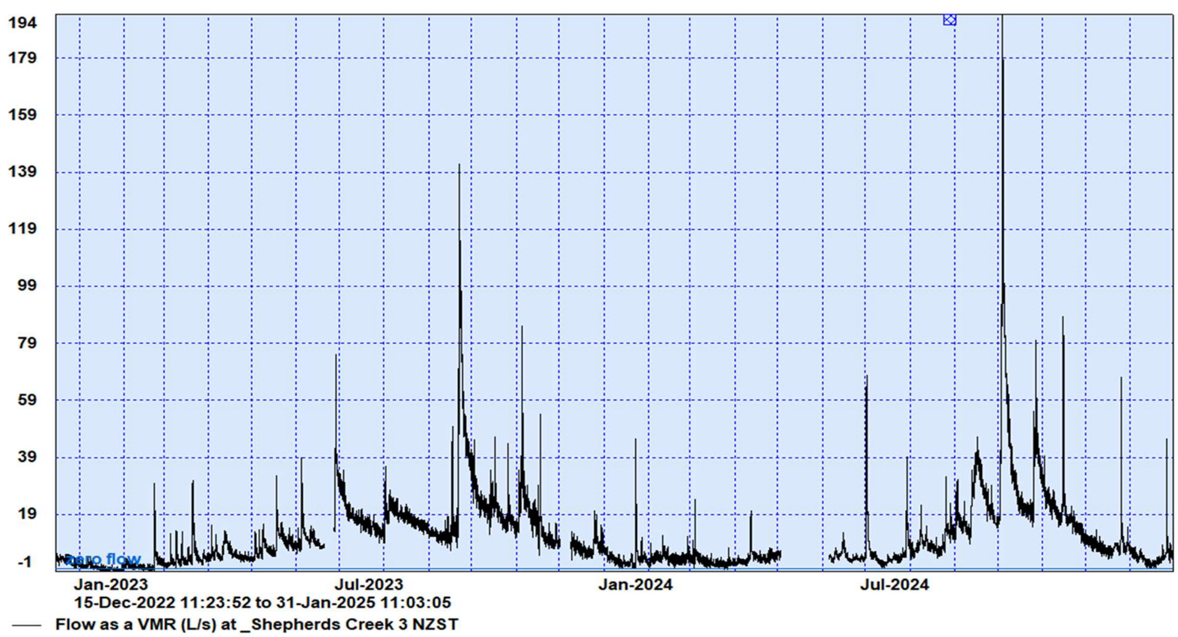

Figure 12: Measured Shepherds Creek @ SC-03 certified flow hydrograph (15 Dec 2022 – 31 Jan 2025)

The hydrograph of Jean Creek at JC-01 with its 1.4 square kilometre upstream catchment is plotted in Figure 13. A significant period of no or negligible flow occurred from 6 February and 25 August 2024. Any flow falling into a data gap from 2 May to 5 June 2024 would also not have been recorded. A further data gap occurred between 1 December and 8 December 2023, which is visible in Figure 13.

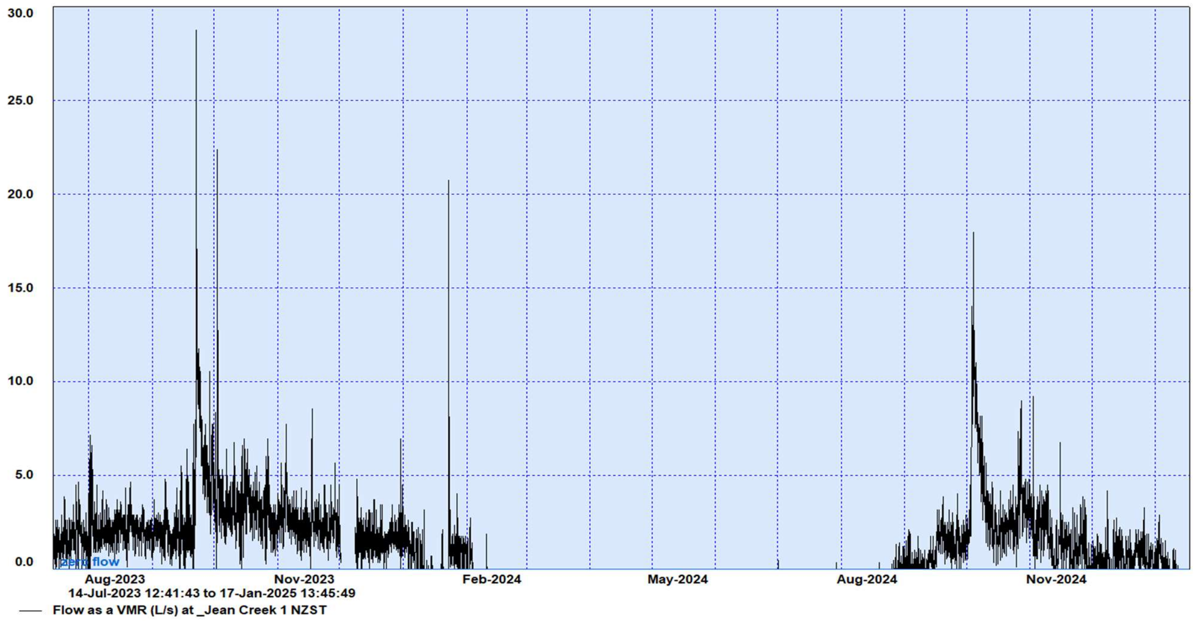

Figure 13: Measured Jean Creek @ JC-01 certified flow hydrograph (14 Jul 2023 – 29 Nov 2024)

The combined flow of Jean Creek @ and Shepherds Creek @ SC-03 defines the catchment yield of the upper Shepherds Creek headwaters with an area of 7.7 square kilometres. Comparing the flow pattern of Shepherds Creek @ SC-03 in Figure 12 with Jean Creek @ JC-01 in Figure 13, the high level of base flow is evident in the Shepherds Creek main stem. Base flow is most often supported by groundwater seepage or spring inflows. Mapping of the distribution of perennially flowing, intermittent and ephemeral creek courses, plus spring locations are shown in Figure 14.

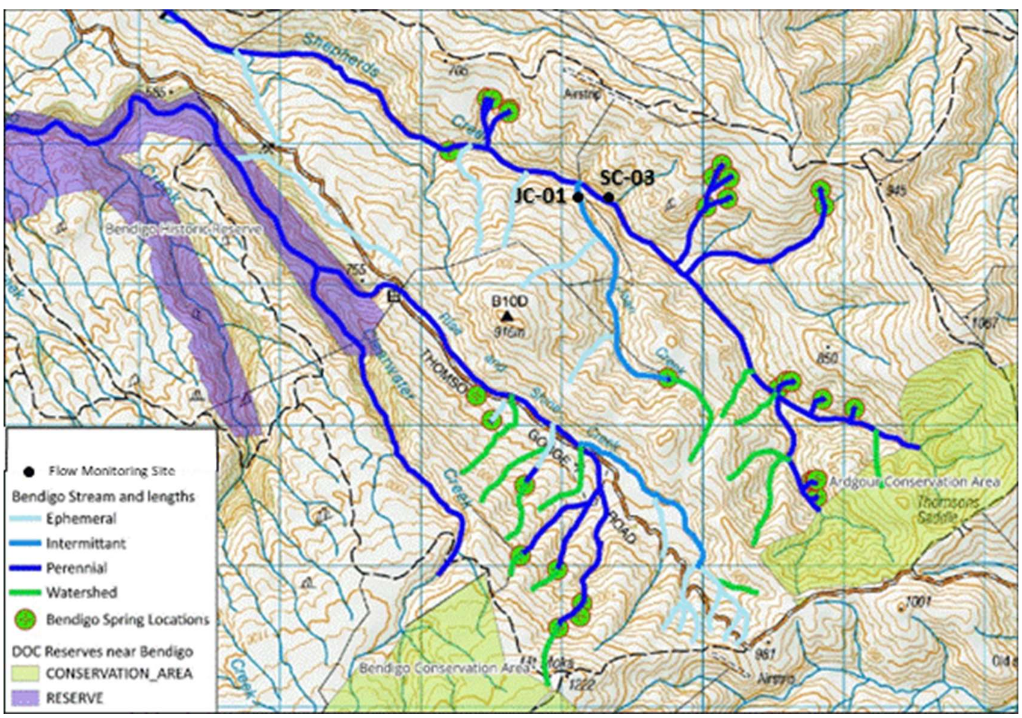

Figure 14: Mapping of stream course status and springs undertaken by Dr Richard Allibone in 2024.

The mapping of water course flow reliability, as perennial, intermittent, or ephemeral, in the upper Shepherds Creek and Rise and Shine Creek catchment provides inferences on creek hydrology. The presence of springs tends to result in the water course downstream of the spring(s) to be recognised as perennial (i.e., long-term consistent or permanent flow). Jean Creek is recognised as ephemeral to intermittent, while the main stem and even Shepherds Creek tributaries on the south slopes of the creek valley are perennial, including small tributaries if the courses are fed by springs. The intermittency of Jean Creek and the permanence of flow in upper Shepherds Creek is reflected in the respective hydrographs of Figure 12 and Figure 13.

The dominance of the upper creek catchment, especially Shepherds Creek above the Jean Creek confluence is displayed in Figure 15. This plot illustrates that while there is a slight increase in flow rate (averaging 1.47 L/s from the Jean Creek confluence to hydrological site SC-01, it belies the 4 kilometres between the hydrological sites and the intervening 4.3 square kilometres (44%) of additional catchment area. The inference is that the fifteen springs mapped in the upper Shepherds Creek catchment provided the bulk of the flow recorded at the lower hydrological flow recorder, SC-01. This is also borne out by the mean and median flow summaries in Table 7.

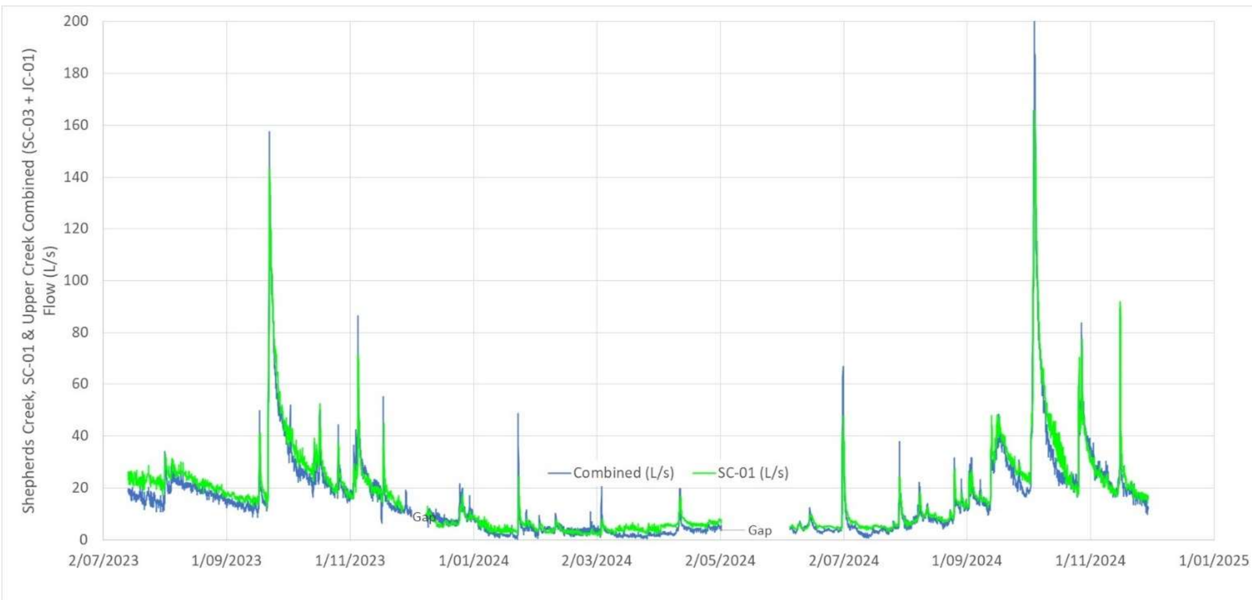

Figure 15: Shepherds Creek @ SC-01 (downstream) and Combined Upper Shepherds Creek @ SC-03 & JC-01

Table 7: Mean, Median flow for Shepherds Creek @ SC-01, and the Upper Catchment @ Jean Confluence

Parameter	Shepherds Creek @ SC-01	Combined Upper Creek Flow by SC-03 and JC-01
Upstream Catchment (km³)	11.9	7.7
Compared data duration (yr)	1.38 (14 Jul – 29 Nov 2024)	1.38 (14 Jul – 29 Nov 2024)
Mean flow (L/s)	17.02	15.27
Median flow (L/s)	14.1	11.85

Mapping of the hydrological monitoring points and the locations of mapped springs in Figure 16 reinforces the impression of high density of such springs in upper Shepherds Creek catchment compared to a low spring density in Jean Creek and downstream Shepherds Creek. A relatively strong regression correlation exists between the flow measured in middle Shepherds Creek (@ SC-01) and the combined upper Shepherds Creek flow (SC-03 and JC-01). A regression correlation coefficient of 0.94 defines a close relationship between these hydrographs. This flow correlation underlines the dominance of the upper catchment in providing 1.2 litres per second per square kilometre of mean flow (L/s/km^2). In contrast, the intervening 4.2 square kilometre middle creek catchment between SC-03 and SC-01 generates only 0.42 L/s/km^2 of additional creek flow on average.

The measured flow contrast between the upper and middle Shepherds Creek catchment is likely to be a function of soil, subsoil permeability / moisture retention dynamics, groundwater base flow, and topographic effects on net rain falling in each part of the catchment. It is also considered that the discrete groundwater systems within slope failures and springs emerging at the toes of slumps are more concentrated in the upper catchment, augmenting flow constancy measured at SC-03, especially on the slopes above the true right of the Shepherds Creek main stem.

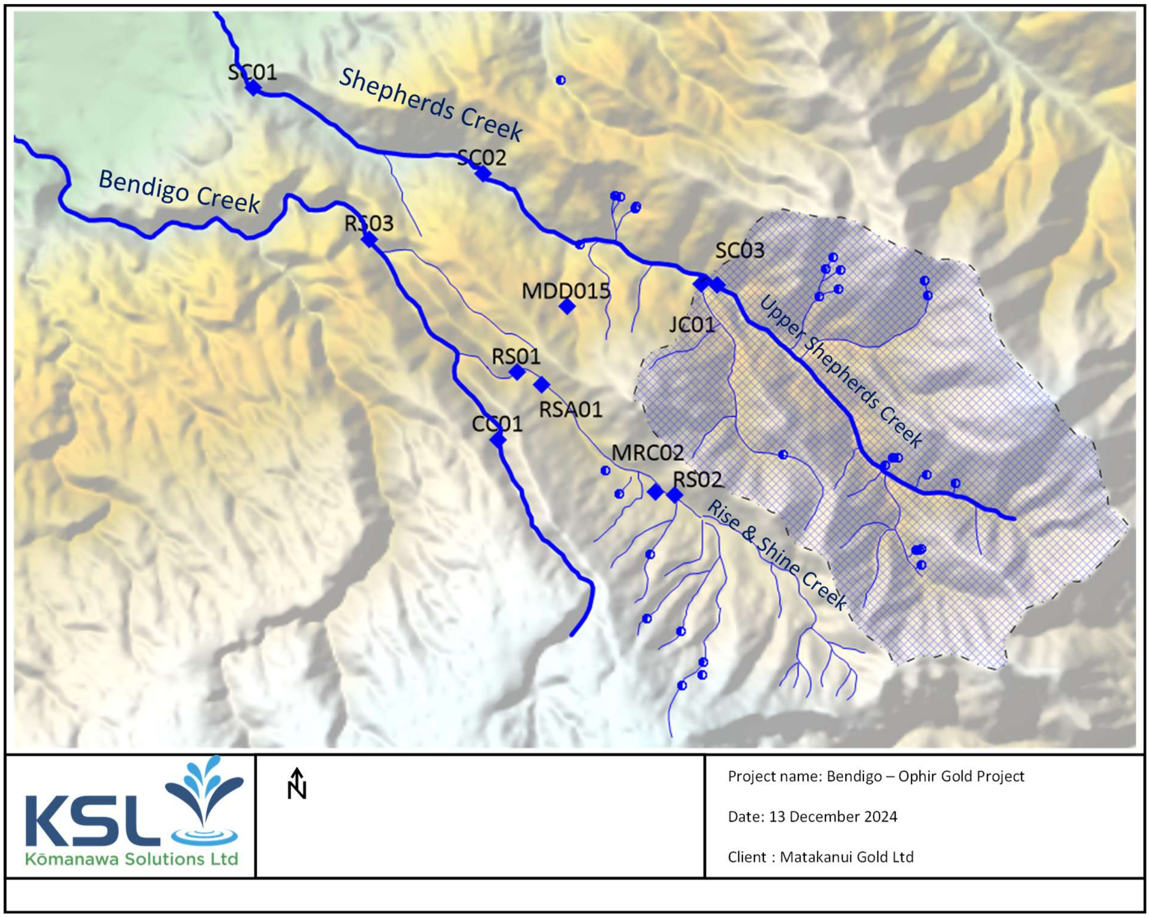

Figure 16: Upper Shepherds Creek catchment (hatched), incl. springs and flow sites, SC-01, SC-03, & JC-01

3.1.1.1 Shepherds Creek Runoff Coefficients

The upper Shepherds Creek catchment measured at Shepherds Creek @ SC-03 and Jean Creek @ JC-01 has a measured set of records of 1.5 years and 92% completeness of flow measurements. The Srex rain gauge record covered the same period, with 100% completeness of rainfall measurements. Taking the whole measured period, the measured rainfall and flow normalised to catchment-wide runoff depth, long-term runoff coefficients were calculated as monthly, mean of months, and mean whole period coefficients. In order to illustrate the change in rainfall and calculated runoff coefficients, Table 8 and Figure 17 list and display these coefficients across 16 months of 2023 and 2024 with concurrent rain and creek flow.

The temporal and spatial trends in runoff coefficients for the upper Shepherds Creek catchment in its existing state reveal the following:

- In a temporal context, runoff declines in low rainfall trend periods, e.g., the summer, autumn, and early winter of 2023 -24,
- Jean Creek has a significantly lower runoff coefficient overall and is particularly affected by accumulating dry conditions,
- As the runoff coefficients are catchment area normalised, the role of the Jean Creek is highlighted as relatively minor in the catchment yield of the Upper Shepherds Creek catchment, and
- The runoff generated by rainfall falling in the upper catchment is as little as between 11 – 15%, indicating that losses to evapotranspiration and lesser ground infiltration are substantial in the overall water balance.

The relative values of runoff coefficients are further examined using measured creek flow in the Shepherds Creek catchment. Table 8 lists the calculated runoff coefficients as the ratio of creek flow and rainfall within calendar months from August 2023 and November 2024. The monthly delineation of runoff coefficients illustrates the effects climate influences, primarily solar radiation, air & ground temperature, and wind run that have composite effect on net evapotranspiration. Summer, autumn, and early winter have the lowest runoff coefficients. These observations correlate with seasonal soil-moisture patterns under the same influence. The above pattern of runoff coefficients reinforce the seasonal pattern of much of the discharge of Shepherds Creek catchment being in late winter and spring.

Table 8: Upper Shepherds Creek Rainfall and Calculated Runoff Coefficients (Monthly and Whole Period)

	Rainfall @ Srex	Creek Flow Runoff Coefficient (decimal)		
	Rain Total (mm)	**SC-03**	**JC-01**	**Combined**
Aug-2023	17.2	0.421	0.051	0.472
Sep-2023	82.4	0.129	0.017	0.146
Oct-2023	39.2	0.233	0.034	0.267
Nov-2023	55	0.130	0.018	0.148
Dec-2023	40.4	0.073	0.015	0.087
Jan-2024	49.8	0.027	0.004	0.031
Feb-2024	30.8	0.052	0.000	0.052
Mar-2024	10	0.079	0.000	0.079
Apr-2024	40.8	0.041	0.000	0.041
May-2024	58.8	0.044	0.000	0.044
Jun-2024	20.6	0.092	0.000	0.092
Jul-2024	55	0.082	0.000	0.082
Aug-2024	99.8	0.122	0.007	0.129
Sep-2024	34.6	0.405	0.038	0.443
Oct-2024	31.8	0.229	0.016	0.245
Nov-2024	46	0.071	0.005	0.077
Mean of Months:	44.5	0.139	0.013	0.152
Whole Period:	718.2	0.128	0.054	0.114

Figure 17 graphs the pattern of monthly calculated runoff coefficients on the basis of measured historic flow data at SC-03, JC-01 and SC-01. The mean of months, which is close to the annual, runoff coefficient approximated 0.15 for the Upper Shepherds Creek catchment in 2023-24.

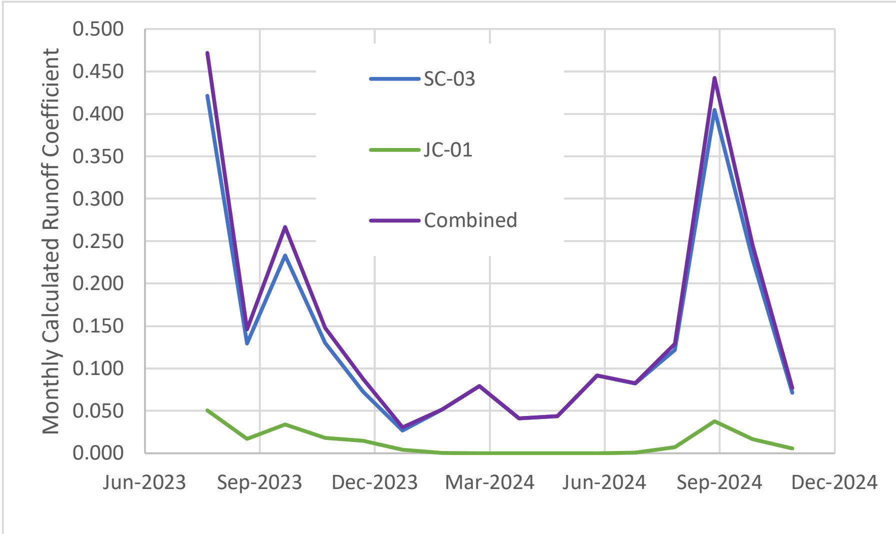

Figure 17: Upper Shepherds Creek Temporal Trend in Calculated Runoff Coefficients (Monthly)

The examination of Upper Shepherds Creek runoff coefficients highlighted the small proportion of precipitation (i.e., approximately 15%) that serves to generate creek flow. Significant losses to evapotranspiration and wetland or riparian evaporation are evidently manifest in the upper creek catchment around Thompsons Saddle.

3.1.1.2 Shepherds Creek and Irrigation Diversion

Shepherds Creek downstream of hydrological site SC-01 is not gauged nor equipped with flow measuring equipment. However, approximately 300 metres downstream of the SC-01 flow measuring site, the creek waters are abstracted for irrigation using an offtake weir under consent number RM17.301.15. This consent allows Tarras Farm Limited Partnership to take creek water at a rate of up to 27.78 L/s[5], as it replaces a deemed permit (mining privilege) prior to 2021.

Figure 18 plots a representative time series of measured creek water abstraction under this consent and measured collated and in water meter record WM0023, which is attached to consent number RM17.301.15. Abstraction plotted in Figure 18 continued across the summer, autumn and early winter until 21 June 2023. Abstraction resumed in early September 2023 and continued until the end of the meter record on 4 March 2024. The abstraction was thus somewhat restricted by the physical availability of water in Shepherds Creek.

The seasonal abstraction aspect is examined in Figure 19 which plots measured creek flow at SC-01 (blue line) and net creek flow after the subtraction of concurrent creek water abstraction (grey columns). Creek water abstraction is indicated by the white space between the natural flow curve and net creek flow. This reveals that the creek barely flows downstream of the point of water take for significant periods encompassing late spring, summer, autumn and even early winter. Net flow passing through the water take structure in appreciable quantities is largely restricted to winter and early spring. Consent number RM17.301.15 allows the holder to abstract year-round (i.e., 1 July to 30 June).

The net creek flow indicated by grey columns in Figure 19 represents the quantity of creek water that passes the irrigation intake structure and infiltrates to groundwater in the downstream creek course. Some losses to riparian evaporation may also remove part of the residual creek flow. Shepherds Creek rarely extends to flowing into the Lindis River, largely restricted to brief and infrequent floods when surface flooding connects them.

[5] 27.78 litres per second is essentially equivalent to 100,000 litres per hour, which is the metric conversion of 1 Otago Head of water relevant to mining privileges under the various issues of the Mining Act and converted to deemed permits to water under Section 413 of the Resource Management Act 1991.

Figure 18: Plot of metered water taken from Shepherds Creek downstream of BOGMP hydrological site SC-01

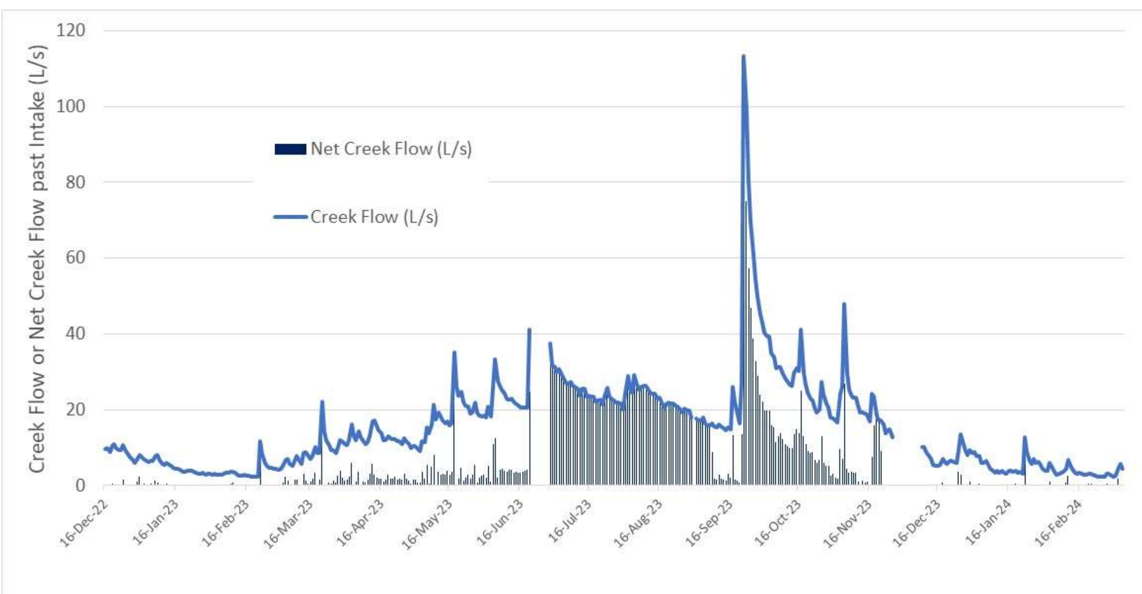

Figure 19: Shepherds Creek flow at SC-01 compared to net flow beyond the point of take

3.1.2 Rise and Shine Creek

Rise and Shine Creek is a tributary of Clearwater Creek, which in turn coalesces with Bendigo Creek. The BOGMP has two baseline flow measuring sites on Rise and Shine Creek, as listed in Table 9 and mapped in Figure 9 and Figure 16.

Table 9: Summary of Bendigo – Ophir Gold Project hydrological flow sites on Rise and Shine Creek

	Easting (NZTM)	Northing (NZTM)	Start Date	End Date at download	Catchment Area (km^2)	No. of Years	Elevation (m AMSL)
Rise & Shine Creek, **RS-01** (Downstream)	1317713	5016973	15/12/2022	31/01/2025	4.710	2.1	711
Rise & Shine Creek, **RS-02** (Upstream)	1318918	5016027	15/12/2022	31/01/2025	2.864	2.1	759

The downstream Rise and Shine Creek hydrological flow site, RS-01, lies adjacent to Thompsons Gorge Road at the stockyards. The Rise and Shine gully was mined using hydraulic sluicing over several decades, working alluvial gravels deposits. The 1:250,000 scale geological Qmap of the area shows a 35 hectare extent of Q1a (Holocene) alluvial fan deposits in the base of the Rise and Shine gully. Otherwise, the remainder of the Rise and Shine Creek catchment is floored in schist rock, predominantly TZ 4 of the RSSZ. Figure 20 and Figure 21 show the measured hydrograph at the two Rise and Shine hydrological monitoring sites, RS-01 and RS-02, respectively.

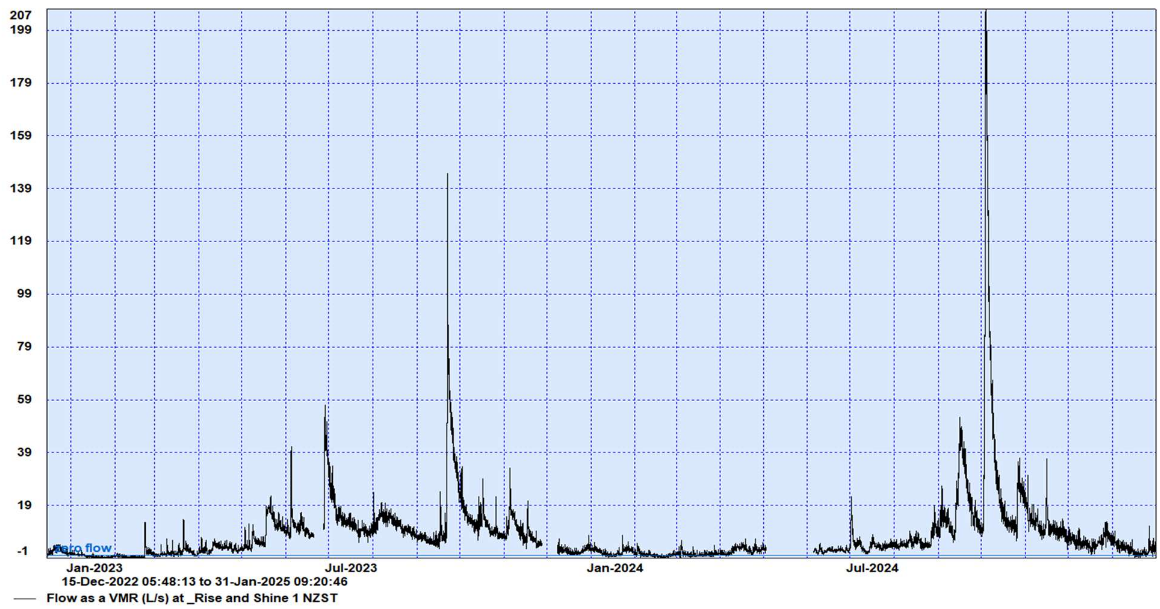

Figure 20: Measured Rise and Shine Creek @ RS-01 certified flow hydrograph (15 Dec 2022 – 31 Jan 2025)

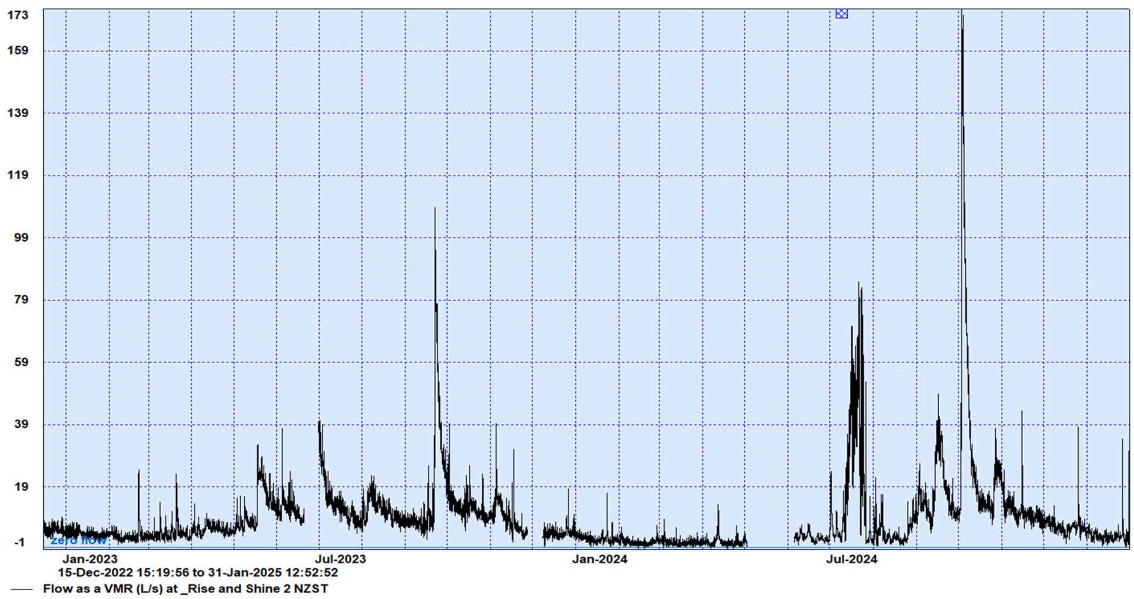

Figure 21: Measured Rise and Shine Creek @ RS-02 certified flow hydrograph (15 Dec 2022 – 31 Jan 2025)

In comparing Figure 20 and Figure 21, an obvious departure is between RS-01 and RS-02 in the period 9 June 15:00 to 26 June 2024 18:00 where the RS-02 rose substantially above those of RS-01. Since the anomalous flow upstream is not registered downstream during a base flow period, the anomaly is not considered credible, and thus excluded from further comparison, including Figure 22. The combined hydrographs of the Rise and Shine flows, with recordings between 9 June 15:00 to 26 June 18:00 excluded from the RS-02 recorded, are plotted in Figure 22.

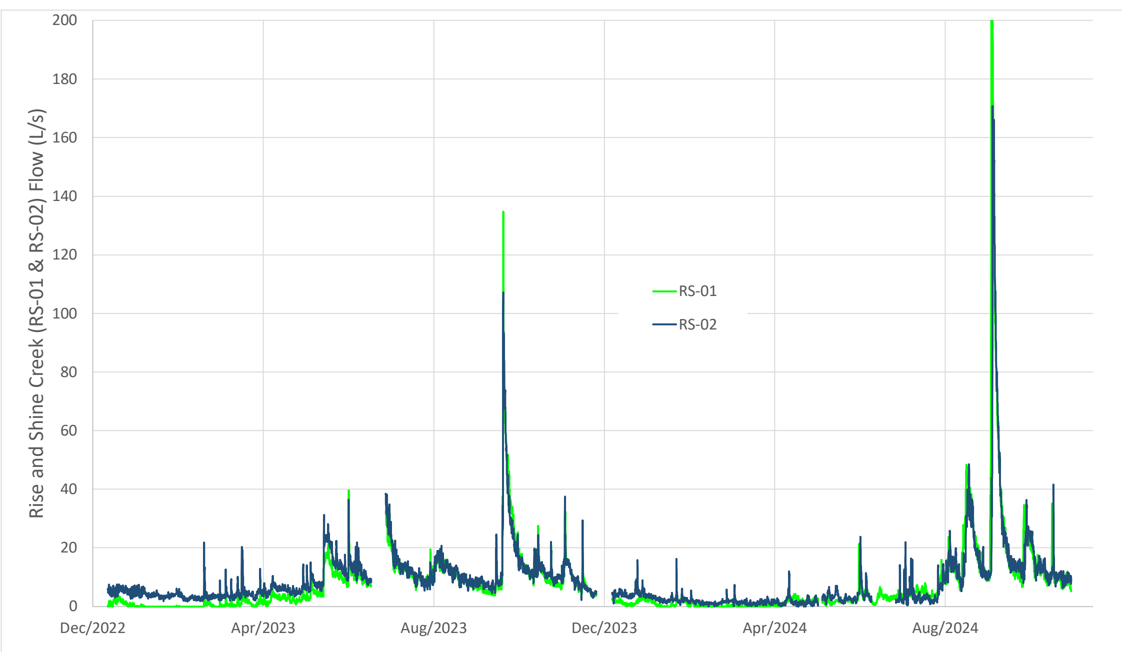

Figure 22: Rise and Shine Creek @ RS-01 (downstream) and RS-02 (upstream), with RS-02 anomaly removed

An examination of Figure 22 reveals that the downstream flow site records a lower concurrent flow than the upstream site. Simple mean and median flow statistics for the Rise and Shine flow measuring sites are listed in

Table 10. The mean and median flow rates also reveal a decrease on flow rate from upstream to downstream sites.

Table 10: Mean, Median flow for Raise and Shine Creek @ RS-01 and RS-02

Parameter	Rise and Shine Creek @ RS-02 (Upstream)	Rise and Shine Creek @ RS-01 (Downstream)
Upstream Catchment (km^3)	2.86	4.71
Compared data duration (yr)	1.38 (15 Dec 2022 – 29 Nov 2024, with anomalous data from 9 June 15:00 to 26 June 2024 18:00 removed)	1.38 (15 Dec 2022 – 29 Nov 2024)
Mean flow (L/s)	8.82	7.62
Median flow (L/s)	5.6	3.4

Several possibilities for the discrepancy may be listed:

- Flow measuring discrepancy at either or both measuring sites,
- Partial underflow of measuring site RS-01 through highly permeable materials such as alluvial gravel deposits or sluice tailings, or
- Effects of pumping from Rise and Shine Creek onto the Battery Ridge for drilling purposes[6].

No conclusion could be made as to which of the above sources of discrepancy was more probable.

3.2 Surrounding Catchments

3.2.1 Bendigo Creek

Bendigo Creek rises in the headwater streams of Rise and Shine, Clearwater, Left Branch, Right Branch, Perrys, and Aurora creeks in the Dunstan Mountains, primarily within Bendigo Station land holdings. The wider catchment rises to an elevation 1,590 metres AMSL near Mt Apiti on the crest of the Dunstan Range and collects into the Bendigo mainstem before passing out onto the surface of the Bendigo Aquifer and infiltrating to the underlying water table before the Bendigo Loop Road ford. Figure 23 maps the general outline of the creek catchments. A flow gauging site was established in 2020 on the main stem of Bendigo Creek for the purpose of measuring the environmental performance of the irrigation abstraction managed by Bendigo Station Ltd, which is mapped in Figure 23. A 2021 technical report for ORC undertook a correlation based on a fragment of Bendigo Creek flow from 10 July 2020 to 4 August 2020 and the concurrent flow recorded at Lauder Creek @ Cattleyards (Stewart, 2021). The flow relationship between Lauder Creek at Cattleyards was essentially 10 times that of Bendigo Creek at the Bendigo Station hydrological site with a regression correlation coefficient of 0.95 (95%). Bendigo Creek at the Figure 23 'gauging site' mean flow and seven day Mean Annual Low Flow ($MALF_{7d}$) hydrological statistics were estimated at 120 and 33 L/s, respectively.

[6] Matakanui Gold Ltd has commissioned diamond drilling investigations in the neighbouring Shepherds Creek catchment that require water for filling and maintaining water levels in mud pits. Pumps were set up taking water from Rise and Shine Creek to lift abstracted water to tanks on the overlooking ridge and gravity flow water to the drill sites generally within the Shepherds Creek catchment.

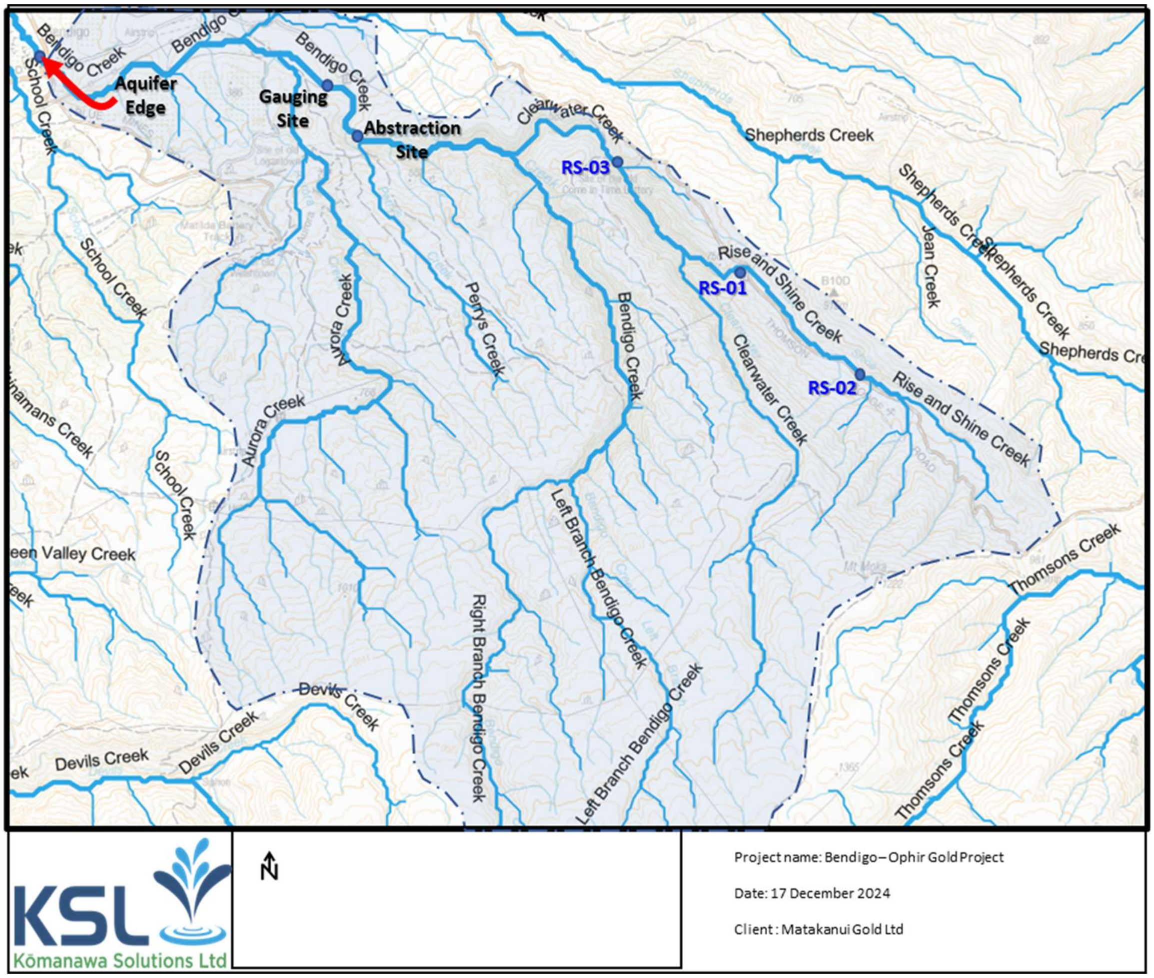

Figure 23: Bendigo Creek main creek tributary names, plus location of abstraction & flow gauging sites

The BOGMP hydrological sites on Rise and Shine Creek are otherwise the sole other sources of hydrological information for the creek. Otherwise, a study was made into the tendency of Bendigo Creek to lose water into its bed once the bed changed from schist rock to alluvium (Bright, 2020). The synthesis of a campaign of creek gauging was that the creek primarily began losing flow to the ground while still in the gorge-like section upstream of the Bendigo Loop Road ford. The position of the most downstream loss of flow would shift up and down stream in response to creek flow and evaporation conditions. Periods of high and accumulating rainfall have resulted in Bendigo Creek flowing beyond this point in a creek channel that is maintained by these infrequent flood flows that may be separated by periods of five years or more. Otherwise, the creek very rarely achieves flow beyond the eastern edge of the Bendigo Aquifer at the Bendigo Loop Road ford, presumably due to enhanced infiltration capacity over the aquifer.

Accordingly, the Bendigo Aquifer connects to the Clutha River via seepage through the aquifer. Figure 24 illustrates the hydrological connects of Bendigo Creek and Shepherds Creek schematically, mapping the flowing creek catchments. In each case, as earlier and separately noted, the creek catchments terminate by infiltrating the entirety of their flow to valley floor alluvial aquifers. In this manner the respective creeks make connection to their respective downstream surface water catchments only indirectly.

Bendigo Creek has a single significant abstraction at the renewed Bendigo Station Ltd intake, as indicated in Figure 23. The abstraction is authorised under consent number RM17.301.15, which allows primary allocation up to 50 L/s. The surface water take utilises a submerged siphon intake, pipeline, and water storage ponds on the southern Bendigo Terrace. The consent application was made in 2017 to replace deemed permit numbers

WR1233CR and WR3908CR amounting to 3 Otago Heads of water (83.4 L/s). Consent was finally granted in July 2021 prior to the expiry of the deemed permit provisions of the Resource Management Act later that year. The water take has been fully operational for the last ten years.

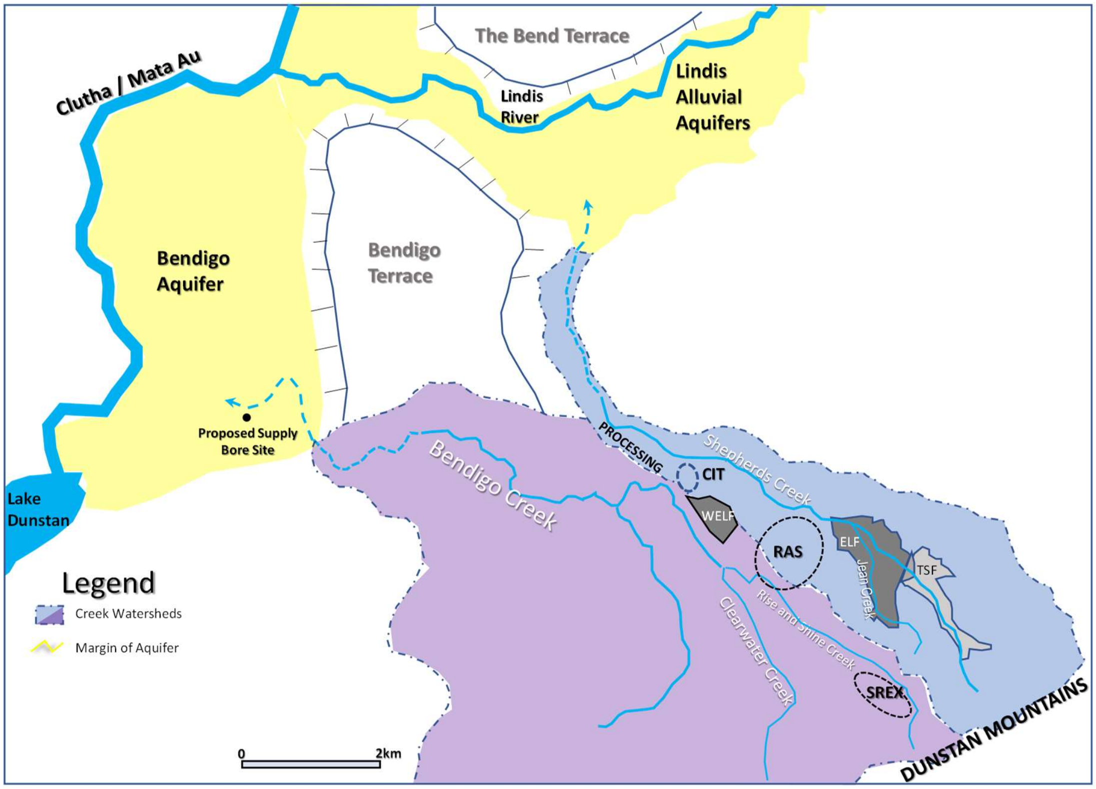

Figure 24: Creek catchments and their terminations with aquifers, including proposed gold pit locations

3.2.2 Lindis River

The Lindis River is a significant tributary of the upper Clutha River / Mata Au, carrying 2.2% of the flow reporting to the Clutha Arm of Lake Dunstan. The Lindis River as measured at long-term hydrological flow sites decreases in flow rate of low flow statistics such as $MALF_{7d}$ and ARI seven-day low flows (see Table 11).

Table 11: Upstream (Lindis Peak) and Downstream (Ardgour Road) Low Flow Statistical Comparison, including Naturalisation of Ardgour Road

Hydrological Flow Site	Hydrological year (July - June)			
	$MALF_{7d}$ (L/s)	Q_7,5y (L/s)	Q_7,10y (L/s)	Q_7,20y (L/s)
Lindis at Lindis Peak	1,626	1,053	956	893
Ardgour Rd (Actual)	252	169	150	----
Ardgour Rd (Naturalised)	*1,935*	*1,270*	*1,158*	*1,085*

Note: Q_7,*X*y - a statistical estimate of the lowest average flow that would be experienced during a consecutive 7-day period with an average recurrence interval (ARI) of *X* (5, 10, or 20) years. Light, green-shaded and italicised values are naturalised for upstream irrigation abstraction. Ardgour Rd (Naturalised) refers to the calculation of the natural flow that would report to the hydrological monitoring site were it not for water abstraction and/or diversion out of catchment.

The Lindis catchment covers 1,059 square kilometres and is a steep catchment with rolling hills in the north (peak elevation 1,925 metres), dropping to alluvial plains in the south and joining the larger Clutha/Mata-Au river at an elevation of 220 m. The headwaters of the catchment are largely within native grassland or remnant native pasture, while the lower catchment is improved pasture comprising exotic grass species and often irrigated. Figure 25 shows the distribution of irrigated agriculture within the wider catchment, which reinforces the assertion that intensive, irrigated land use is concentrated in the lower catchment and mostly downstream of the Lindis Peak hydrological flow recorder site. The explanation for the drop in river flow rate during low flow is the large scale abstraction of surface water of the Lindis main stem and tributaries, plus groundwater takes from the valley alluvial aquifer especially the Lindis Alluvial Ribbon Aquifer. Figure 25 maps the Lindis Catchment, the two principal flow monitoring sites, and areas of irrigated exotic grass pasture.

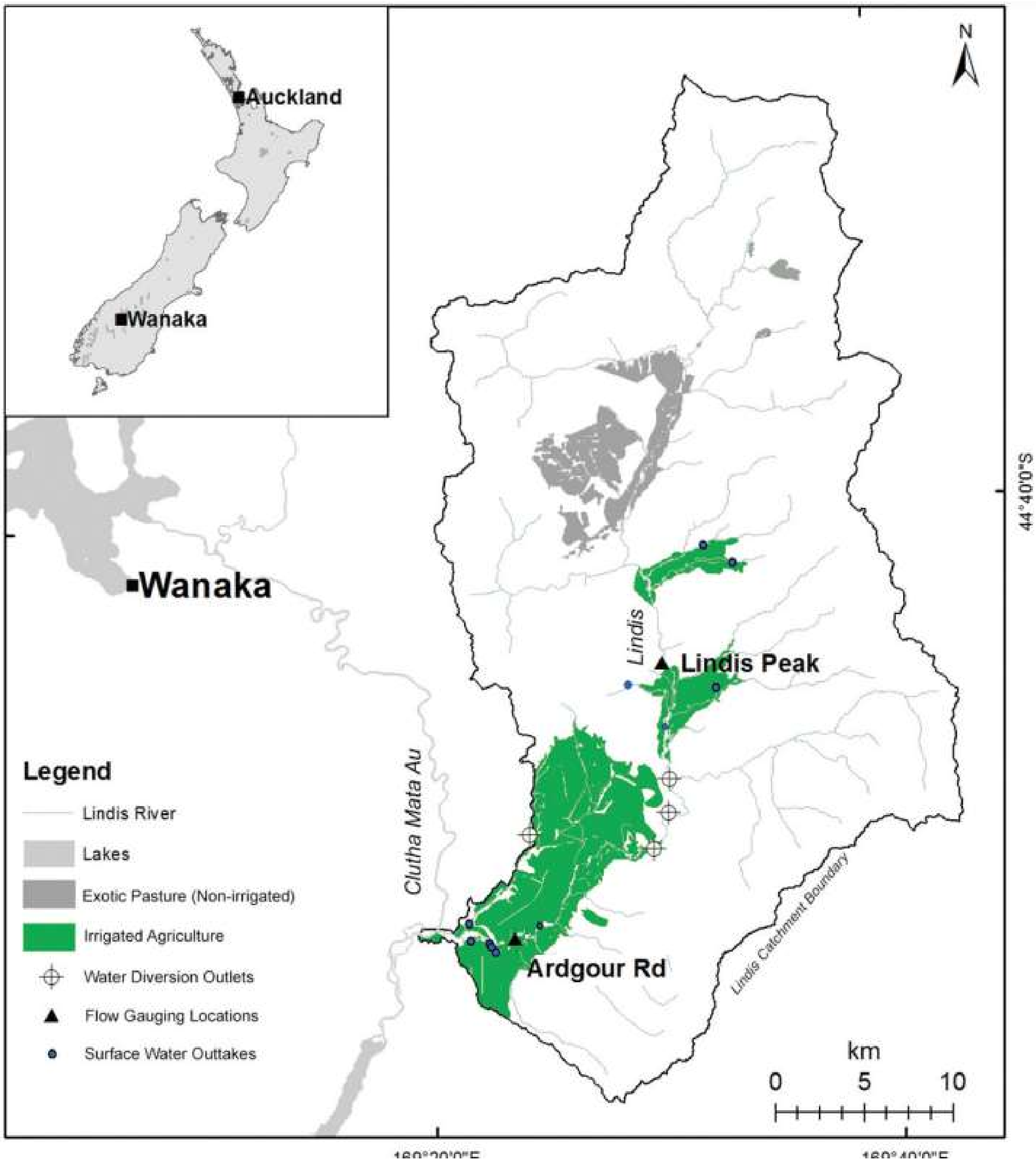

Figure 25: Distribution of irrigated pasture and flow recorder sites in Lindis Catchment (Kingston et al., 2021)

Figure 26 maps the distribution and abstraction rates of water takes as surface water takes and groundwater takes. Many of the current and proposed groundwater bores and galleries deplete the flow of the Lindis or

Clutha River / Mata Au. Indeed, the design and proximity of the bores / galleries makes it clear that surface water depletion is the intention. The largest surface water takes on the Lindis River main stem are diverted into water races trained along the eastern edge of the valley floor aquifers (i.e., Rutherford and Ardgour races) or out of the catchment into the Tarras Creek catchment (i.e., the Jollie race to Tarras).

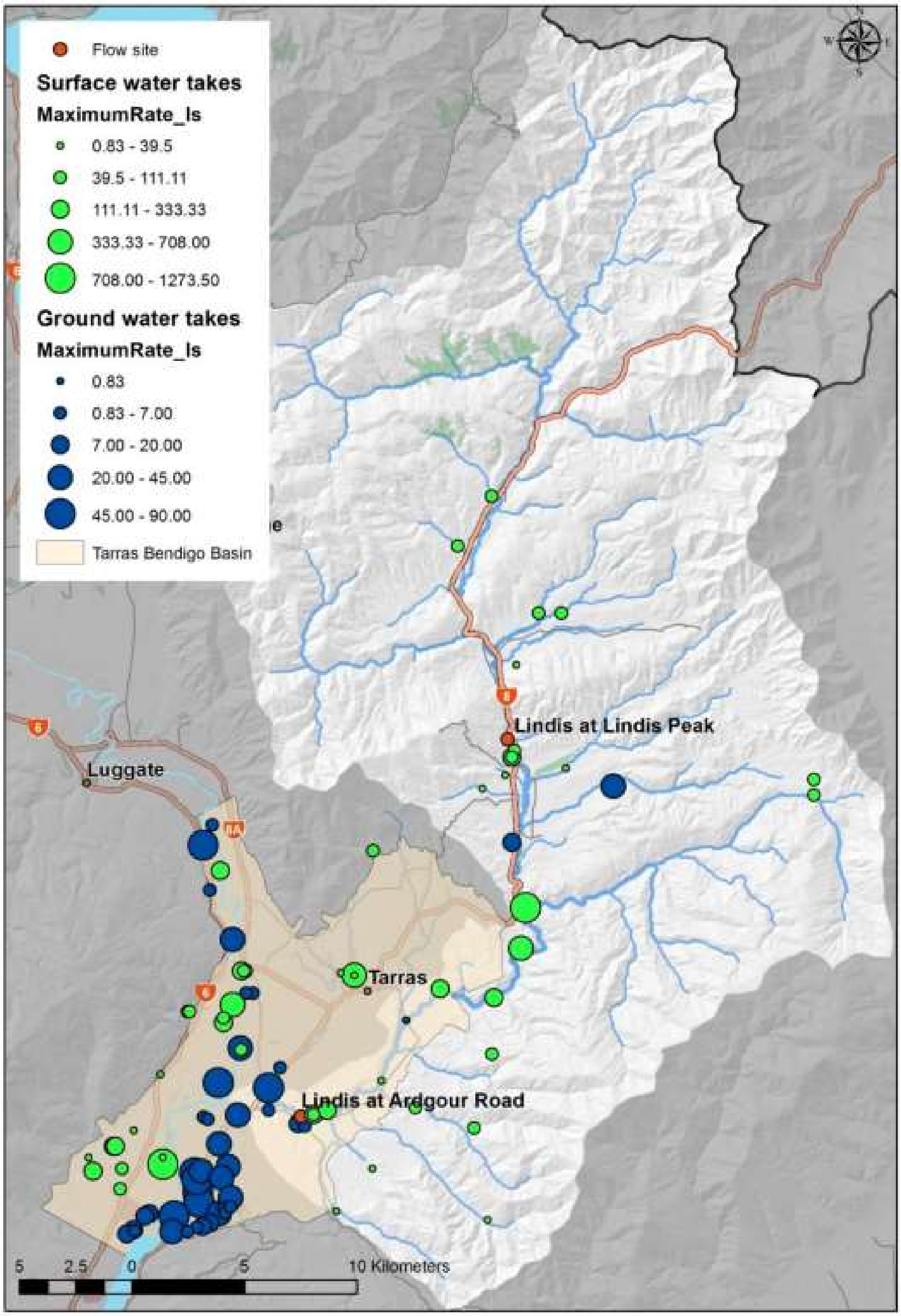

Figure 26: Water use intensity within Lindis catchment and adjoining aquifers (Otago Regional Council, 2015)

Due to these conditions, the Lower Lindis River could be classed as intermittent during Hydrological Drought[7]. The causes for depressed lower river low flows during the irrigation season (broadly early October to late April) are the diversion of water out of the catchment and the abstraction and irrigation in ways that serve to evapo-transpire most of the abstracted water applied to pastures. Therefore, up to 1,600 L/s that would have otherwise accrued to river flow at the Ardgour Road hydrological flow site near the Clutha confluence is taken out of the hydrological system and does not return at the height of the irrigation season. Figure 27 illustrates the changes in the hydrographs of the upstream Lindis Peak hydrological site compared to the downstream Ardgour Road site as the season of 2006-07 hydrological year cross from on-irrigation to the irrigation season and back again (Otago Regional Council, 2015). The onset of more intense irrigation in early January causes the Ardgour Road river flow trace to detach from the that of the upstream site and drop in response to diversions and irrigation onto dry pastures. These factors make the lower Lindis Valley a water-short area.

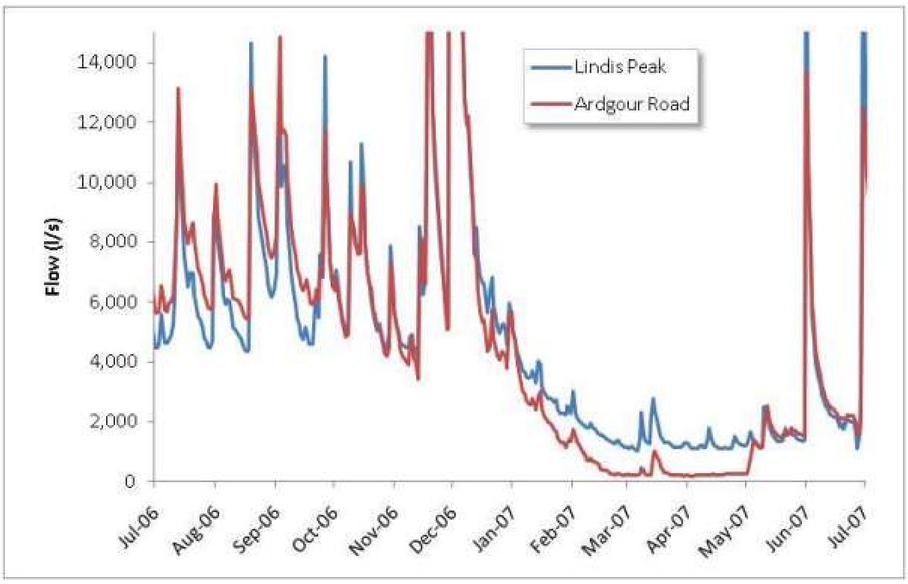

Figure 27: Comparison of Lindis Peak and Ardgour Road site hydrographs (Otago Regional Council, 2015)

A water resource reform process and parallel water abstraction consent renewal process was termed Plan Change 5A (subtitled: Lindis: Integrated water management). The plan change hearings, and Environment and High Court appeals resulted in a raft of provisions being taken into the operative water plan, and the granting of 35 year duration consents for all existing takers of surface or groundwater in the Lindis catchment. The Plan Change 5A provisions in the operative Regional Plan: Water, include an irrigation season minimum flow of 550 L/s affecting all water takes except non-depleting groundwater, a winter-time minimum flow of 1,600 L/s, and adherence to a Flow Management Plan to be prepared by the Lindis Catchment Group.

Significantly, the existing water race intakes that current take water on either side of Archies Flat in the middle Lindis must be converted to groundwater galleries abstracting water and pumped into a pipe network thus abandoning the existing water race network, These provisions are not yet in operation through a combination of an interregnum in Otago water policy directions imposed by the previous government, and partly the “five year following operative date” condition forestalling the Flow Management Plan provisions in each water take consent. The planning, design and construction of up to ten new galleries on the Lindis valley floor and tapping the Lindis Alluvial Ribbon Aquifer is also on hold until the policy interregnum has been resolved.

Realistically, the Lindis River catchment is fully allocated. Any new application to take water from the river or a tributary would have significant difficulty, probably following the non-complying pathway through the consent

[7] Hydrological drought is identified by a lack of water in streams, reservoirs and groundwater (Nalbantis & Tsakiris, 2008) and (Van Loon, 2015) as opposed to a lack of rain or soil-moisture.

process and likely requiring the surrender or cancellation of an existing consent with attached allocation in favour of the new application. The Plan Change 5A related water take consents provide for a groundwater gallery with a capacity of 35 litres per second to be installed at site between the Lindis River and the closest approach of Shepherds Creek. The gallery would be authorised by consent number RM17.301.13.V1 and paired with a further upstream gallery to a combined maximum take of 100 L/s. Both galleries would rest in the Lindis Alluvial Ribbon Aquifer.

In its current state, the depleted Lindis River in low flow state also loses flow downstream of Archies Flat by infiltration into its bed, which eventually dries out some river reaches. Flow is retained in other reaches of the lower Lindis River in even the most severe low flows and droughts. It is understood that these perennially saturated reaches of the river are sustained by the interception of the channel and the water table, thus groundwater seepage locally sustains low flows. The river reach around the Lindis at Ardgour Road hydrological flow site is one such perennial flowing reach, one might say pool, in the lower river. Upstream and downstream of this restricted extent of flowing riverbed, dry reaches of bed may be found, especially from late December to middle March in dry years. It is not known to what extent the reformatted irrigation intake system using infiltration galleries and 550 L/s minimum flow would alter the low flow hydrology of the lower Lindis River, although most existing water users receiving replacement consents were not expected to sacrifice reliability of irrigation supply.

3.2.2.1 Lindis Tributary: Cluden Stream

The hydrological flow site on Cluden Stream is detailed in Table 12, and plotted in Figure 28.

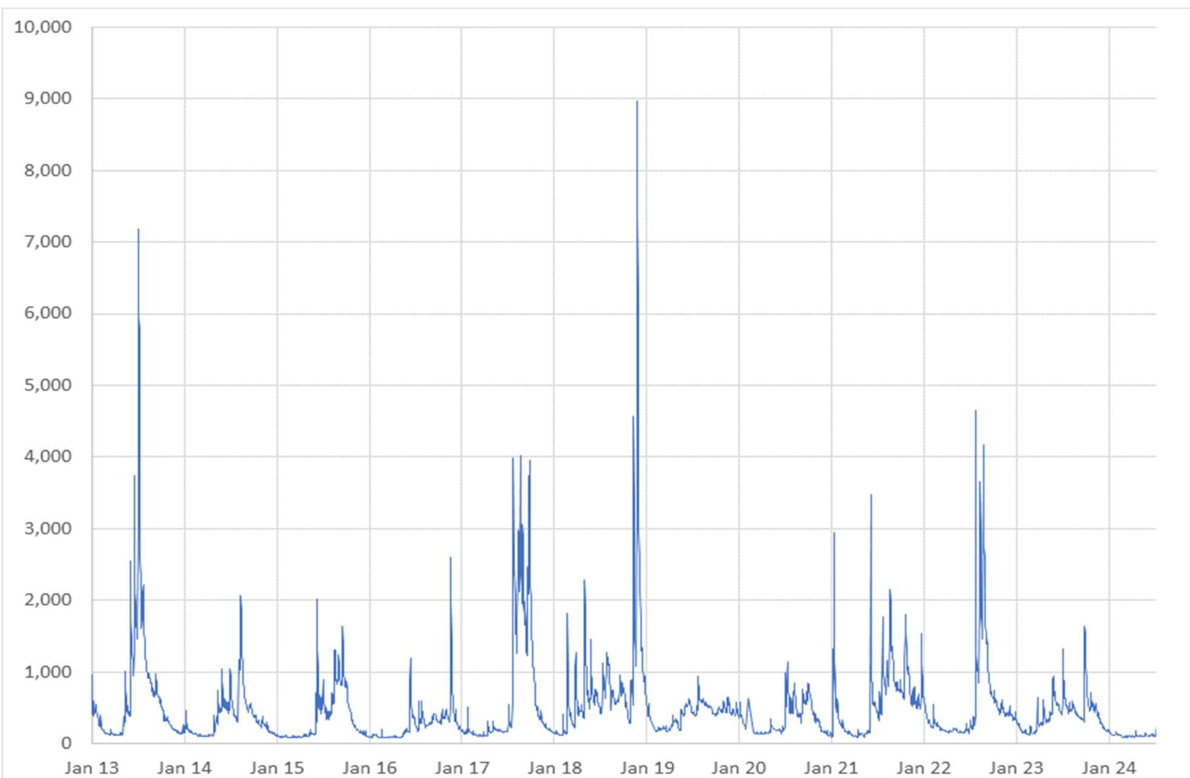

Figure 28: Cluden Stream at Stock Yards flow rate time series in litres per second

Table 12: Summary of Flow Monitoring on Cluden Stream

	Easting (m NZTM)	Northing (m NZTM)	Start Date	End Date	No. Years	Area (km²)
Cluden Stream at Stock Yards	1326703	5032880	21-Nov-12	19-Jul-24	11.6	87*

Note: * The normal catchment area of 115.8 square kilometres for Cluden Stream is truncated by a diversion structure and water race into the neighbouring Coal Creek catchment, therefore the 28.8 square kilometre catchment upstream of the diversion was removed from the area total leaving 87 square kilometres.

The nearly 12 year measured flow record to July 2024 is summarised as mean, median, and $MALF_{7d}$ in Table 13.

Table 13: Summary of Hydrological Flow Statistics of Cluden Stream at Stock Yards, including specific runoff

	Area (km²)	Mean (L/s)	Median (L/s)	$MALF_{7d}$ (L/s)	Specific Mean (L/s)	Specific Median (L/s)	Specific $MALF_{7d}$ (L/s)
Cluden Stream at Stock Yards	87	476	320	113	5.5	3.67	1.3

The hydrograph of Cluden Stream at Stock Yards was employed to make a correlation with the overlapping Shepherds Creek flow record at SC-01.

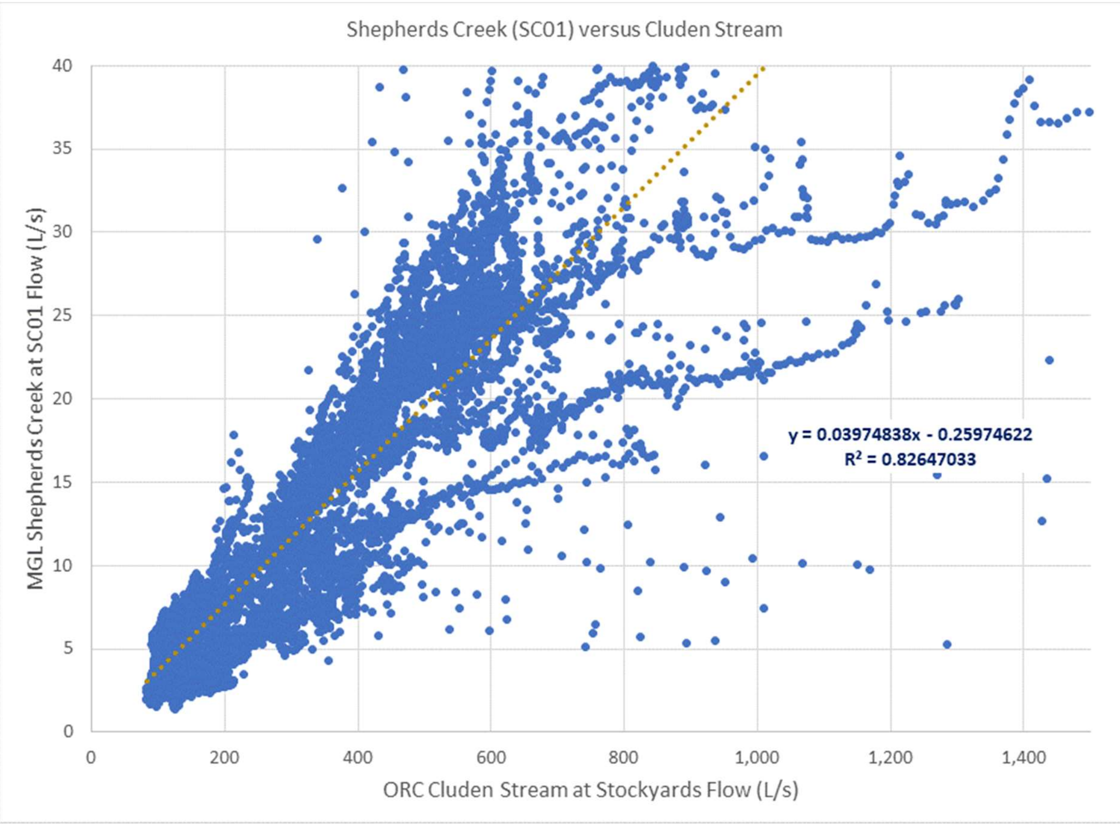

Figure 29: Cross-plot for undertaking regression correlation of Cluden Stream and Shepherds Creek

The regression correlation relationship for 1.5 year period of direct overlap of the Cluden Stream and Shepherds Creek indicated an r^2 correlation coefficient of 0.826 (83%) that points to a high level of concurrency between the two flow sites (see Figure 30 for overlapping hydrographs).

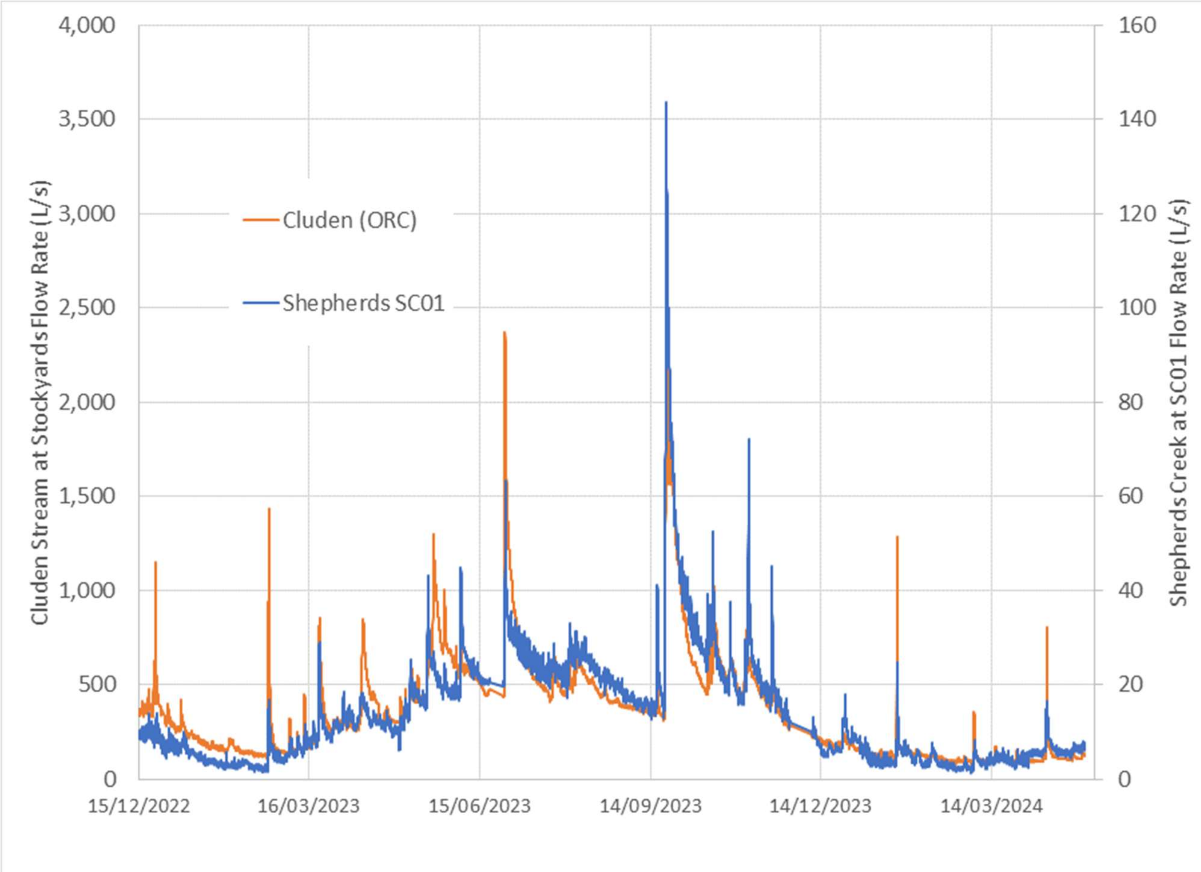

Figure 30: Side-by-side dual axis plot of Cluden Stream and Shepherds Creek flow in concurrent record

The utility of this correlation is discussed in section 3.1.1 and Table 6, but in brief allows for a more statistically significant characterisation of Shepherds Creek hydrology.

3.2.3 Upper Clutha River / Mata Au and Lake Dunstan

The Clutha River / Mata Au River is fed by the outflows of Lake Hāwea and Lake Wānaka with subsidiary inflows from the Cardrona, Luggate and Lindis tributaries entering the river downstream of the lakes. The Hāwea River is under artificial control since the 1960s due to the construction of the Hāwea Dam across the river and forming the modern-day Lake Hāwea. Contact Energy manipulates the gates on the dam according to the flow requirements of the Clyde and Roxburgh hydro-electric power stations further downstream on the Clutha River System. The Clutha River / Mata Au passes the western edge of the Bendigo Aquifer, passing through a delta complex, and entering Lake Dunstan at Crippletown. The lake level and the transit of flow from large rivers is managed by the operation of the Clyde Dam by Contact Energy. The Clyde power station is a base load generator, allowing Lake Dunstan to be managed within a relatively tight lake level range. That consented operating range is from 193.5 to 194.5 metres above mean sea level (AMSL), i.e., 1.0 metres. This makes the Clyde Dam somewhat 'transparent' by passing inflow from the Upper Clutha or Kawarau river systems using water turbines or, more rarely, spillway gates.

Manipulating Hāwea Dam outflows is the main means of managing the generation of power. Figure 31 displays concurrent hydrographs of Clutha River at Luggate (located 28 kilometres upstream of Lake Dunstan) above a similar hydrograph for Lake Dunstan during the hydrological year of 2019-20. The Clutha at Luggate river stage plot shows the effect of a block of Lake Hawea water released for the Hawea Dam as rectangular rises and falls in river level particularly manifest during winter and spring. These blocks of released lake water are over-printed upon a more gradual pattern of building and decaying river flow related to the dynamics of the Lake Wānaka catchment, particularly in the later winter - spring of 2019 (August – October 2019).

Figure 31 also illustrates the narrower range of water level fluctuation and greater degree of hydrograph volatility at Lake Dunstan relative to the upper Clutha River / Mata Au. The annual water level range for Lake Dunstan for 2019-20 was approximately 0.8 metres, whereas the comparable river stage range of Clutha at Luggate was approximately 3.0 metres.

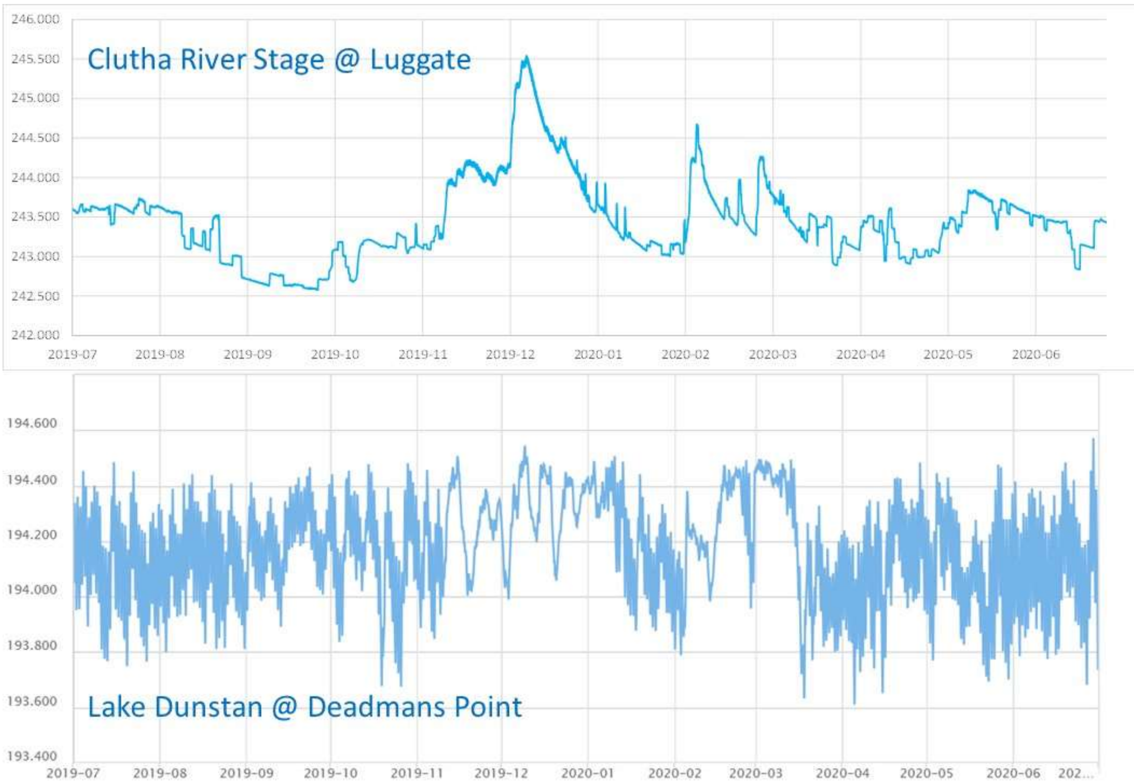

Figure 31: Coinciding river stage and lake stage time series across the 2019 – 20 hydrological year

The overall fall in Clutha River / Mata Au water level elevation between the Lindis River confluence and Lake Dunstan is estimated as the difference between 210 and 194 metres AMSL, approximately 16 metres. A related aspect to the river gradient is that the north to south hydraulic range in water table levels through the Bendigo Aquifer follows much the same trend and magnitude. Indeed, the aquifer water table gradient is tied to that of the river, and computer groundwater flow modelling has demonstrated that hydrologically significant rates of water exchange operate between the river and aquifer.

3.3 Manuherikia Catchment

Adjoining the Lindis catchment along the eastern slopes of the Dunstan Mountains is the major Clutha / Mata Au tributary, the Manuherikia River. The Manuherikia catchment comprises the Ida Burn and Moa Creek of the Ida Basin, which flow within largely separate catchments that were captured by tectonically mediated headward erosion. Other tributaries are Dunstan Creek, Lauder Creek and Thompsons Creek. The Manuherikia River catchment also has many of the hallmarks of water resource availability shared with the Lindis catchment, including persistent rain shadow effects of the Dunstan and Hawkdun Mountains on catchment water yield, plus the development of irrigation infrastructure with the capacity to take most of the water flowing in the main stem and tributaries (e.g., Hawkdun Creek intakes and race, Falls Dam and downstream main stem intakes).

The upper Shepherds and Rise and Shine Creeks back onto a Manuherikia tributary called Thompsons Creek along the crest of the Dunstan Mountains near Thompsons Saddle. Thomsons Creek and other ORC surface water monitoring sites are listed in Table 14 and representative hydrographs are provided in Figure 32, Figure 33, Figure 34, and Figure 35.

Table 14: Summary of Flow Monitoring Sites in Surrounding Catchments (absent irrigation diversions)

	Easting (m NZTM)	Northing (m NZTM)	Start Date	End Date	No. Years	Area (km^2)
Cluden Stream at Stock Yards	1326703	5032880	21-Nov-12	12-Jan-21	8	87*
Thomsons Creek at Diversion Weir U/S	1329273	5012614	1-Aug-19	30-May-21	< 2	65
Lauder Creek at Cattle Yards	1332350	5016540	23-Sep-08 (big gap 30 Apr 2013 to 17 Aug 2016)	Present	15	74
Dunstan Creek at Gorge 500m D/S	1345070	5032768	3-Mar-20	Present	4	159
Manuherikia River downstream of Fork	1355128	5038960	28-May-75	Present	49	174

Note: * Flow record was already plotted in Figure 28 and Figure 30.

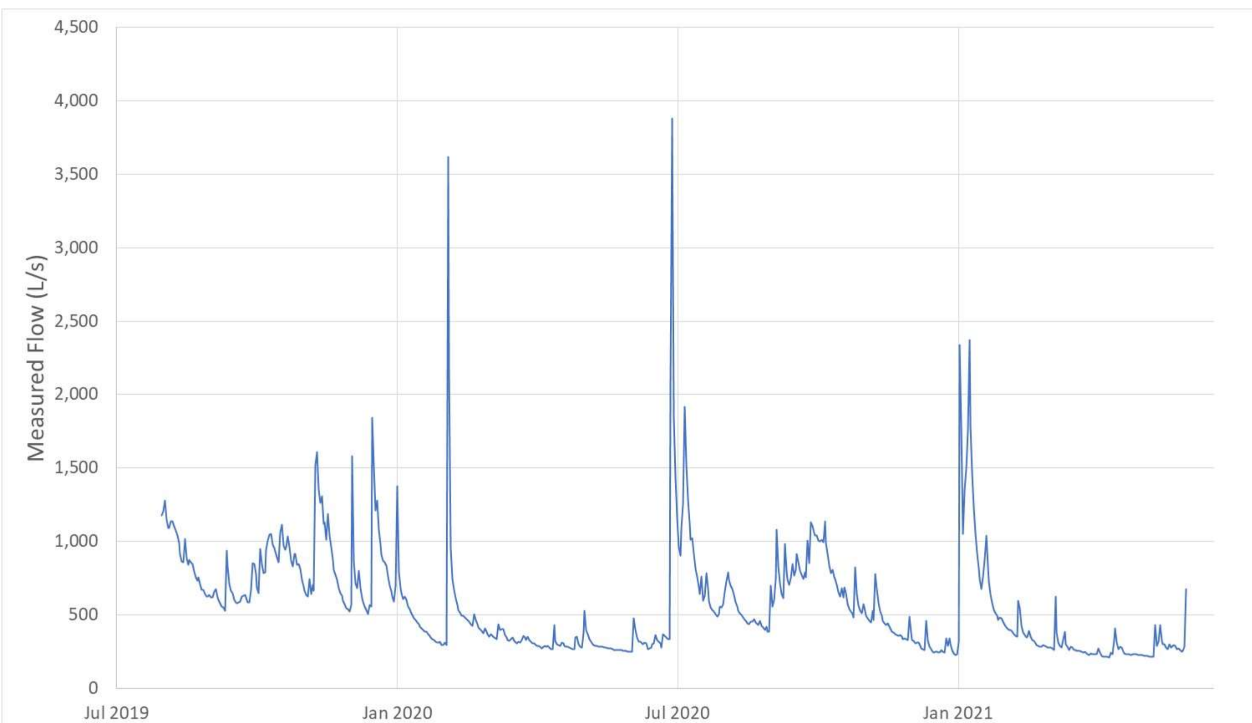

Figure 32: Thomsons Creek upstream of Diversion flow rate time series in litres per second

Thomsons Creek adjoins the upper Shepherds Creek and Bendigo Creek catchment. This flow measurement site is located immediately upstream of irrigation intakes that abstract a significant portion of creek flow for the Matakanui sector of the Omakau Area Irrigation Scheme. The flow site was located to characterise natural surface water inflows to the catchment.

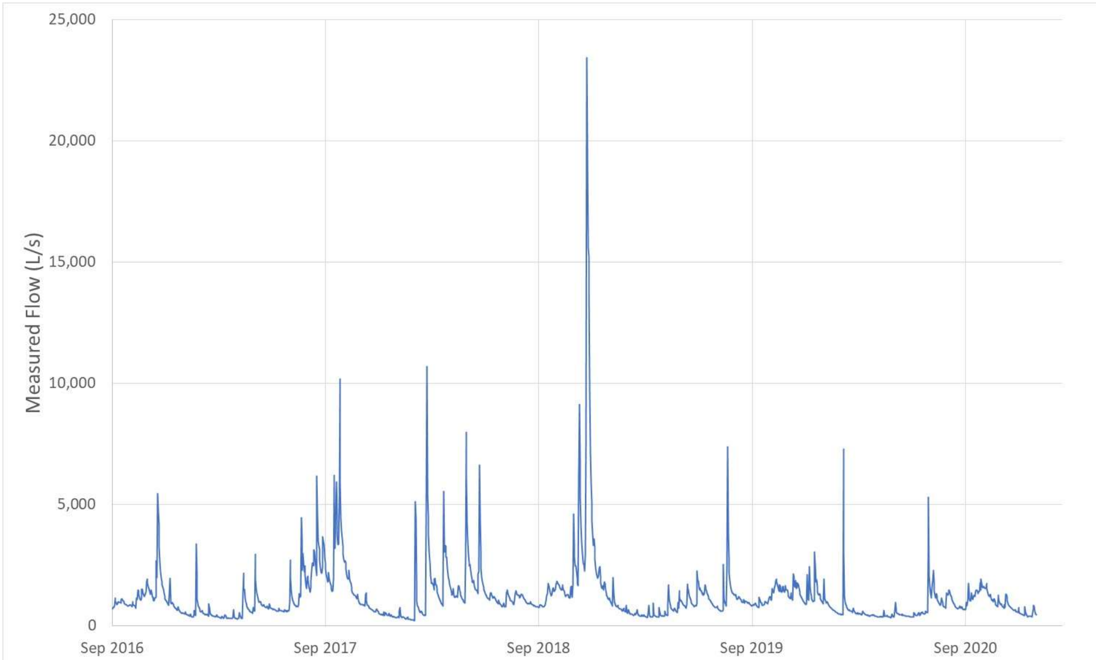

Figure 33: Lauder Creek at Cattle yards flow rate time series in litres per second

This flow monitoring site record on Lauder Creek was utilised by Raineffects (Stewart, 2021) to correlate Bendigo Creek hydrology with the longer period of monitoring on Lauder Creek, and was originally located by ORC to avoid the flow suppression effects of irrigation abstraction that occurs further downstream.

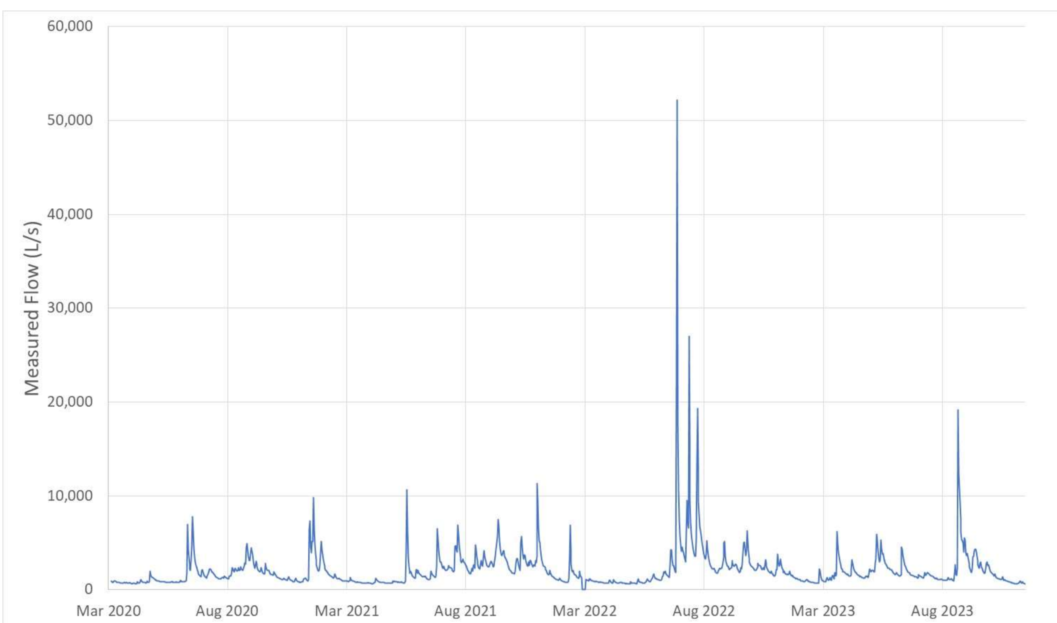

Figure 34: Dunstan Creek downstream of Gorge flow rate time series in litres per second

The Dunstan Creek flow management site is largely unaffected by downstream irrigation abstraction and was sited in order to reflect Manuherikia catchment inflows. Dunstan Creek is a substantial tributary of the Manuherikia River, rising in a high precipitation zone of the of the Dunstan and Hawkdun mountains.

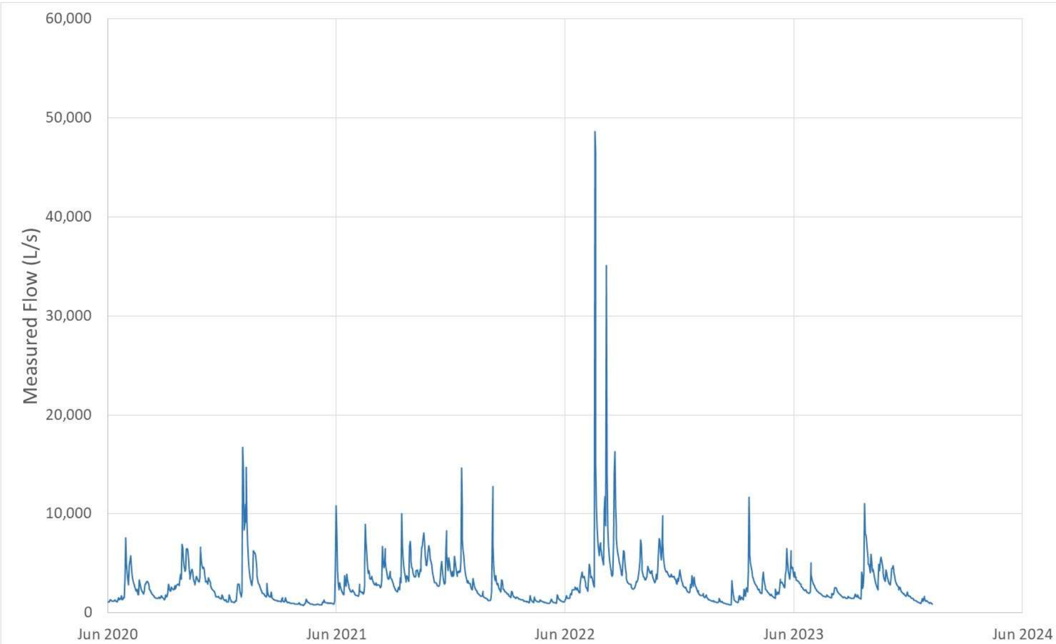

Figure 35: Manuherikia River downstream of Fork flow rate time series in litres per second

This river flow management site for the Manuherikia River is largely unaffected by downstream irrigation abstraction at Falls Dam and was located in order to reflect Manuherikia catchment inflows. A summary of the statistics that could be drawn from all of the above hydrological flow records are listed in Table 15. In order to normalise these statistics, specific runoff is also provided in Table 15.

Table 15: Summary of Hydrological Flow Statistics of Nearby Catchments with ORC Flow Monitoring

	Area (km^2)	Mean (L/s)	Median (L/s)	$MALF_{7d}$ (L/s)	Specific Mean (L/s)	Specific Median (L/s)	Specific $MALF_{7d}$ (L/s)
Cluden Stream at Stock Yards	87	478	320	113	5.5	3.67	1.30
Thomsons Creek at Diversion Weir U/S*	65	576*	468*	235*	8.86*	7.2*	3.62*
Lauder Creek at Cattle Yards	74	1,140	840	245	15.4	11.35	3.31
Dunstan Creek at Gorge 500m D/S	159	2,115	1,557	668	13.3	9.8	4.2
Manuherikia River downstream of Fork	174	3,144	2,442	940	18.0	14.0	5.4

Note: * Thompson Creek Upstream of Diversion has a short flow measurement period less than two years, not suitable for the calculation of hydrological statistics.

There is a degree of commonality in the specific runoff statistics for mean, median and $MALF_{7d}$ flow rate statistical indices. Acknowledging that Thompsons Creek has a sub-optimal length of record for the development of statistics and the Manuherikia River has disproportionate areas of the upstream catchment from high altitude Hawkdun Mountains with elevated catchment flow yield, Lauder Creek and Dunstan Creek specific runoff statistical values fall close to each other. Cluden Stream stands out with the lowest specific runoff statistics, even after the removal of the diverted upper catchment from the catchment area total used in calculated specific runoff.

The differences between the eastern catchments of Lauder Creek and Dunstan Creek, and the western catchment of Cluden Stream (see Table 13 and Figure 28) points to lower specific runoff on the western flanks of the Dunstan Mountains. As Shepherds Creek and Bendigo Creek catchments are both west-flowing on the western flank of the Dunstan Mountains, the use of correlations with Cluden Stream are more likely to be representative.

3.4 Summary of Investigations

The findings of the investigations undertaken by Matakanui Gold Ltd or commissioned by MGL for the BOGMP may be summarised as follows:

- The Upper Clutha Valley exhibits a substantial pluviographic and hydrographic gradient from the Southern Alps to the valley floors between Bendigo and Cromwell.
- A regression correlation has been undertaken to generate a 75 year synthetic daily rainfall record for the BOGMP rainfall measuring site at Lake Clearwater.
- Comparison of the Lake Clearwater rainfall site with other higher elevation BOGMP rainfall measuring sites at CIT and SRX pits reveals a trend of rising event totals and annual totals with height, and a positive topographic gradient in rainfall towards the Dunstan Mountain crest.
- Rain totals across the BOGMP project area is low by national standards, ranging from 451.5 to 507 millimetres per annum as mean annual rainfall, while the mean annual rainfall for the country is significantly higher.
- The glacial lakes of the Upper Clutha catchment contribute disproportionately to the flow and volume of fresh water coalescing into the upper Clutha River / Mata Au, while rivers and creeks in the Bendigo area have substantially lower specific runoff rates due to the shadowing of rainfall imposed by encompassing mountain ranges.
- The BOGMP mineral handling and processing sites lie within the Shepherds Creek and Bendigo Creek catchments, which are small Clutha Catchment tributaries, neither of which extend surface flow to their respective downstream main stems.
- Both creek catchments proposed for mining are also relied upon for single irrigation creek water intakes that are consented to abstract a large part of the seasonal catchment yield, and the water used in pastoral (grazing) or horticultural irrigation.
- Small lengths of flow measurements of creek flow are available for both creek catchments. These fragments have been extended using regression correlation with the flow records of nearby creek or stream catchments (Cluden Stream and Lauder Creek), allowing a statistical characterisation of mining site hydrology.
- The Lindis River, which is the main stem of Shepherds Creek, has significantly altered irrigation season hydrology due to the actions of upstream intakes and diversions. Summer low flows are currently characterised by discontinuity of surface flow and enduring hydrological connection only feasible *via* subsurface flow (interflow in the hyporheic and groundwater zones).
- The Clutha River / Mata Au and Lake Dunstan are an important bolster to hydrological condition in the Bendigo area. Substantial reliance is made upon the river and lake for abstraction and replenishment of the Bendigo Aquifer while that groundwater resource is under seasonal abstractive pressure. The hydrological quantification of these water resources, including the long-term combined mean flow of 271 cubic metres per second, indicate the robustness of the river and lake to sustain the water demands from the surrounding districts.
- The current Existing Environment characterisation of the BOGMP site creek hydrology is broadly consistent with longer-term hydrological records of other water courses draining the Dunstan Mountains.
- Examination of Shepherds Creek with multiple hydrological flow monitoring sites reveals that the generation of runoff is concentrated in the headwaters and upper catchment in the presence of upland landscapes, wetlands, landslide springs, and higher rainfall with lower temperatures. Long-term measured runoff coefficients for the upper creek catchment range between 0.11 and 0.15, while small tributaries, with part of the main water course being ephemeral, range between 0.01 and 0.05.

4 Project Description & Proposals for Mining Complex Development

4.1 Surface Mining Proposals

The essential proposition of surface mining is that the mineralised schist of the geochemically altered RSSZ within the RAS gold deposit would be extracted after the overlying, non-gold-bearing schist concurrently quarried to expose the ore. The BOGMP includes a open cut pit with an ultimate depth of 250 metres into the schist overburden across the Battery Hill ridge line to expose the mineralized ore along the floor of the pit for extraction. The mine pit would extend north-eastward approximately 1,035 metres, with a pit base that would extend downwards to an approximate base of 395 m AMSL.

The pit would be started and extended from the Rise & Shine side of the Battery Hill ridge, beginning in the gully floor and extending north-eastward. Initial excavation would in this manner be able to take both ore and barren schist rock. The overlying barren schist rock is termed overburden and is generally broken into blocks and finer spoil to be handled separately for emplacement in ELFs, formerly referred to as waste rock stacks. The ore assayed as being above the cut-off gold grade would be trucked to the Run Of Mine (ROM) stockpile for crushing, grinding and feeding into the ore processing plant.

The pit would extend through the Battery Hill ridge line and across the flanks of the slopes overlooking Shepherds Creek while steadily extending 'down-dip' along the alignment of the RSSZ mineralised zone. The water table would be intersected by the starter pit and management of seepage would begin early in the pit development. While the RAS pit also crosses the creek bed in the Rise and Shine creek valley, it is intended that the creek flow would be diverted into a large diameter culvert pipe that crosses the pit edge and allows the creek to continue on its original course after leaving the culvert.

The surface mining at the RAS open cut pit would extend over approximately nine years, excluding the initial construction phase. The early years of pit excavation would be dominated by the task of reducing the overburden within the Battery Ridge straddling the pit axis. The last few years of pit development would have a smaller proportion of overburden compared to ore extraction. Concentric batters would be cut into the pit slopes for optimal slope stability. A principal haul road would be formed on the northern side of the oval pit in view of the shorted haul route to the main ELF.

4.1.1 Engineered Land Forms

ELFs would be developed in the upper valley floors of Shepherds Creek upstream of the Jean Creek confluence, plus the floor of Jeans Creek. The Shepherds - Jean creek ELFs would eventually coalesce as they grew in height and extent. The Shepherds ELF would be placed so as to buttress the TSF on its downslope side within the Shepherds Creek valley. A further ELF called Western ELF would be placed west of the RAS pit and straddle the Shepherds – Clearwater catchment boundaries.

4.2 Underground Workings Proposals

The underground proposal to access the gold ore would extend from the base of the open cut pit floor, while extending mining panels down dip along the RSSZ to extract ore with minimal overburden waste rock. The underground workings would be initiated from sub-horizontal drives parallel to the strike[8] of the fault plane of the TGF and 10 m to 30 m below the plane of the TGF into the RSSZ. The principal ore extraction technique would involve a fan of holes that would be bored upwards towards the TGF to produce drill spoil containing gold ore (i.e., mineralised schist). The upward groupings of holes are termed an overhand stope, or stopes in the multiple. The repetition of drives and stopes would progressively extend the underground workings down-dip along a width of 100 m - 150 m across the strike of the TGF. Underground workings would begin vertically beneath the northeast wall of the open cut pit at a roof depth of 440 m AMSL. The approximate duration of

[8] Strike is a geological term referring to an orientation to the horizontal scribed across a structural plane. In the case of a fault surface, if the fault dips (is inclined) north than the strike would be east, i.e., the strike line runs west to east.

underground mining would also be seven and a half (7½) years. The down-dip progression would extend 830 m to the north-north-east at a mean rate of 105 m per year. The total ultimate footprint area of the workings would be 16 ha in extent, plus tunnel roadways and other developments outside of the immediate stope zones.

Ore and any waste is conveyed to the mine portal for trucking to the ore processing plant. Much of the tailings are ground and filtered to form an injectable paste by slurry line for return into completed stopes and some 'robbed' pillars. The extraction of ore using the underground stopes would thus be balanced by the emplacement of cemented tailings paste, as is common practice in modern underground gold mining (Cacciuttolo & Marinovic, 2023). Roof collapse and development of a goaf[9] above the underground workings would not be practised, which has important implications in precluding the possibility of goaf subsidence.

4.2.1 Access Drifts & Other Drives

The mining panels of the underground would be accessed by three main tunnelled drives:

- The Access Drift ('decline') from the surface portal,
- Roadways following the dip of the RSSZ providing entry to mining panels, and
- Strike-parallel drives arranged across strike.

The subsurface access is supported by a portal at the land surface. The portal area arranges the wheeled traffic transition, pipelines and other services exchanged between the surface and subsurface infrastructure.

4.2.2 Mining Stopes

Underground drives would be developed by drill & blast, with stopes excavated using a fan of drills from the drive below. Crushed ore would be conveyed to the surface as the stopes are extended. The ore would also be delivered to the ROM stock pile and feed the ore processing plant.

Water rock tailings would be ground into a paste with cement and water added to form a viscous paste that is pumped within HPDE or steel pipelines until it arrives at the sites of emplacement (Cacciuttolo & Marinovic, 2023). Following ore processing the tailings would be injected into the completed mining panels to fill the panel void from floor to roof. Since the tailings are cemented and once solidified would have permeability in the order of 1 x 1^{-10} m/s as hydraulic conductivity, the workings backfilled with tailings would be effectively the same or lesser permeability of surrounding rock.

4.3 CIL Ore Processing Plant

The ore processing plant would be sized to accept and process 1.5 million tonnes of ore each year at a peak capacity of 4,500 tonnes per day. The Carbon In Leach (CIL) process would involve:

1. **Crushing and Grinding**: The gold ore is crushed into a fine powder.
2. **Cyanide Leaching**: The ground ore is mixed with a cyanide solution to dissolve the gold.
3. **Adsorption**: The gold-cyanide solution is passed through activated carbon to adsorb the gold.
4. **Elution**: The loaded carbon is subjected to elution to strip the gold from the carbon.
5. **Electro-winning or Smelting**: The gold is recovered either by electrowinning or smelting, depending on the chosen recovery method. Refinement of the recovered gold may also be required depending on impurities.

The main fluid and solid end-products of processing would be as follow:

- Decanted process water, which would be classed as mine-impacted water,
- Tailings, either:
    - Tailings (conventional wet tailings) from surface mining destined for the TSF, or
    - Cemented tailings paste for injection into underground workings,

[9] Goaf definition: That part of a mine from which the ore has been extracted and the space more or less filled up with caved rock.

- Gold concentrate, and
- Minor sludges and precipitates.

The decanted mine water would join the mine water loop to be reused in processing. If required to be discharged, the decanted mine water would be monitored for principal contaminants and potentially treated before discharge.

4.4 Waste Management from Surface Mining

4.4.1 Engineered Land Forms (ELFs)

Waste rock not part of the ore stream would not go into processing and would instead be diverted directly into ELFs. The emplacement of waste rock is engineered to avoid the geochemical evolution and mobility of metallic or other contaminants capable of entering water and being released further into the environment.

4.4.2 Tailings Storage Facility (TSF)

Conventional tailings management is envisaged for the Rise and Shine mining complex. The tailings from surface mining would be conveyed by slurry lines to the TSF. Further dewatering of the tailings would occur at the TSF as mine water supernatant separates from settled tailings, leaving a pond of mine water atop the tailings 'beach' and wholly behind the TSF impoundment.

4.5 Waste Management from Underground Mining

There is very little waste rock generated in underground mining, chiefly restricted to tunnels passing through non-ore rock, on the way to stope mining areas identified as being densely concentrated ore bodies (i.e., Shear Zone or auriferous vein materials). Limited quantities of waste rock will be diverted to an appropriate zone of the ELF, or used in CIT pit back-fill.

The overwhelming majority of materials excavated in underground mining would be classed as gold ore and would be conveyed to the ROM pile for feeding into the processing plant. Following ore processing the tailings would be treated, conveyed back underground and cemented tailings would be injected into the completed mining panels to fill the panel void from floor to roof.

4.5.1 Cemented Tailings Paste

The emplacement of cemented tailings would provide *de facto* pillar support to the roofs of the underground workings. The return of underground tailings to the mined stopes would also avoid the need to dispose of tailings as conventional tailings into the TSF, following the completion of surface mining. It may be expedient and low-impact for a small portion of the tailings from underground ore to be emplaced at the TSF, especially in the decommissioning phases of the underground workings.

4.6 Water Supply

A number of mine operations and ancillary services would require make-up water as part of their process. While many of the processes, such as ore processing or dust suppression, would be capable of utilising mine water, some would specify clean water, such as drinking water. At different stages of the project operations, the mine water available would not be sufficient to provide make-up water for the processes capable of using mine water. External make-up water would be required to fill out the water requirement. So, balancing of water requirements and mine water availability would necessitate the availability of clean water top-up. The initial commissioning phase of the processing plant operation would also ideally be provided by the clean water supply from the Bendigo Aquifer.

The proposed maximum rates and volume of groundwater takes (i.e., the consenting envelope) are set out in Table 16, below.

Table 16: Proposed Consent Pumping Rate and Volume Requirement

	Rate or Volume	Explanation
Instantaneous on daily basis (L/s)	110	Combination of estimated maximum demand and proximity to tested capacity.
Maximum Daily (m^3/d)	9,500	Instantaneous rate of 110 L/s multiplied by 86.4
Maximum Monthly (m^3/month)	285,00	Daily rate multiplied by 30
Maximum Annual (m^3/year)	3,153,600	100 L/s multiplied by 86.4, multiplied by 365

Table 16 outlines the proposed consent envelope rather than the estimated rates of actual use. As outlined above, the dust suppression water demand would be dictated by wind run and soil moisture. The make-up water requirement of the ore processing plant would be moderated by the availability of mine water to augment aqueous throughput. The bore field would be operated to smooth out water throughput rather than provide all requirements. The consent limits in Table 16 should not be confused with the expectations of normal abstraction, which would ordinarily be lower. However, environmental assessments would use the values provided in Table 16, above as a basis for evaluating whether the effects would be acceptable.

4.7 Zero – Discharge Mine Site

The other thing to note is that projections of the operational mine water balance indicated that the mining complex within the mine water management perimeter would be able to function as a zero-discharge facility in normal circumstances. This set of water balance projections determined that the beneficial use of mine-impacted water for ore processing or dust suppression, plus the judicious use of minimal clean make-up water from the bore field and ability to use the TSF as a buffering store for mine-impacted water across periods of elevated water accumulation (i.e., wet spells or wet years) mean little, if any, discharge of mine-impacted water would be required. The direct implication would be that discharge of mine-impacted water to external water bodies such as Shepherds Creek or Rise and Shine Creek would be of short duration and infrequent.

4.7.1 Clean Water Requirement

The mine water balance model was used to estimate the clean water requirement for the main phases of mining operations, including construction, commissioning, continuing operations, wind-down and decommissioning. It was found that the peak clean water make-up water requirement for the BOGMP would be 110 L/s. Much of the water requirement would arise in the first years of mine operation during a period that mine water from pit and underground dewatering surplus would be lowest. Seasonally, the summer and late summer period would entail the highest demand for water for use in dust suppression. Ore processing plant through-put rates and, therefore, water demand would be variable in accordance with the short-term stripping ratio, but not seasonal other than the increase in dust suppression water demand in hot, windy conditions.

4.7.2 Bore Field

It is proposed that a bore field would be established, tapping the Bendigo Aquifer near State Highway 6. Comprising two bores, a duty and stand-by bore, with individual capacities of 110 L/s, the bores would be fitted with electric submersible pumps controlled by Variable Speed Drives (VSDs) for flexibility of the rate of bore pumping. Due to the known high transmissivity of the Bendigo Aquifer, the bore being pumped would experience only nominal amounts of water level decline (drawdown) within the bore chamber of 400 millimetre diameter. The external effects of groundwater level decline is dealt with in more detail in the effects section of the groundwater take assessment document (Rekker, 2025b).

4.7.3 Water Conveyance & Storage Infrastructure

The bore field site lies approximately 6.5 km from the main ore procession area and the clean water reservoir. The supply bore field would connect with the mining complex by a buried HPDE pipeline to the clean water reservoir.

4.8 Rehabilitation

A gold mine is unique in being a temporary industrial setting often within an existing more natural environment. The economic gold resource is finite and the eventual exhaustion of the economically feasible resource is an inevitability. Thus planning for End of Mine Life (EOML), restoration and rehabilitation land or habitats affected by mining relate activities would begin before mining complex construction. The estimated operational mine life would involve 1.5 years of pioneering earthwork to remove overburden, 8.5 years for surface mining followed by 7.5 years of underground mining that begins 4.5 years into the operations period. There is an overlap in the production of surface mining and underground mining. Satellite surface mining pits at CIT, Srex, and Srex East would begin producing late in the operational mine life. The best estimate of EOML is 11 years after the onset of operations. Following the end of each sphere of mining would trigger associated rehabilitation steps.

Much of the restoration and rehabilitation target entails mining-affected land. However, restoration and rehabilitation also includes aquatic environment such as water lines, creeks and wetlands. The EOML would result in the rehabilitation of the mine void remaining after surface mining. Internal pit drainage would be changed to ensure appropriate erosion and sediment control of the pit slopes. A pit lake would form at the base of the mine void.

4.8.1 Creek Bed Rehabilitation

At the conclusion of mining operations some significant modifications to the beds of creeks may be rehabilitated. First among these would be the bed of Shepherds Creek from the Shepherds silt pond to the monitoring site SC-01. During operations, the creek would have been relocated and essentially converted into a rip-rap lined floodway to accommodate access and haul roads, the processing plant and ROM pad.

Rise and Shine Creek would be rehabilitated at two separate zones:

- SRX Pit and ELF creek diversions, and
- Rise and Shine Creek culvert crossing of the RAS pit wall.

These sections of the creek would be restored and rehabilitated to return the beds to stable morphology and enhance potential aquatic organism habitat properties.

4.8.2 Surface Mining Rehabilitation

The rehabilitation of the surface mining elements involves a larger number of elements involved in rehabilitation processes. These elements include -

- Open cut pits,
- Shepherds and Srex ELFs,
- Shepherds TSF,
- Water Management facilities, and
- Haul roads and other disturbed surfaces.

Beyond the mining complex elements named above, the extended environmental effects of surface mining would attract forms of rehabilitation, offsetting restoration or other forms of compensation for environmental impacts that would resemble rehabilitation. This could include progressive decommissioning of drains that altered groundwater flow patterns.

4.8.2.1 Post-Closure Management of the RAS Pit

The RAS surface mining pit would cease operation with the base of the excavation at 385 metres AMSL. Upon the shutdown of dewatering pumps, the dewatering sump(s) would begin to fill, flooding the floor of the pit as a pit lake formed at rates governed by groundwater inflows, incident rainfall and any intentional discharges of mine water into the pit.

The pit lake would have an outlet into the top of the underground mine, so the formation of the pit lake would need to be halted to avoid the lake water entering the underground workings. This restriction would be maintained out of necessity to avoid water interconnection between the post-closure surface pit and the underground workings. Upon the closure of the underground workings and the removal of care & maintenance controls, the surface pit water level would rise towards the penetration of the pit wall by the underground stopes. Renewed dewatering would be instituted to prevent the pit lake from entering the stopes or presenting a water inrush risk. Following the closure of the underground workings, post-closure management would entail the drainage of the closed residual pit into the wall penetration and flow outward to Shepherds Creek via the former surface portal.

The ultimate post-closure state of the con-joined surface and underground workings would include the RAS pit lake over-topping into the pit wall penetration of the underground workings with the pit lake water level controlled by either the sill level elevation of the penetration or the over-top level elevation of the former underground portal. Management of the post-closure mine water discharge from the underground portal would form part of the post-closure water quality planning, including passive treatment and the most appropriate mode of the water re-joining the creek system.

4.8.3 Underground Mining Rehabilitation

The use of cemented tailings paste is both an avoidance of operational effects on groundwater, and rehabilitation of the subsurface workings in terms of the longer-term effect that would potentially otherwise occur. Rehabilitation of the mine portal area following the EOML would also be undertaken. Any subsidence surface cracking around the portal zone would be filled and covered. Filling covering rehabilitation of surface cracking would mitigate potential effects such as infiltration of runoff with effects on slope stability and changed groundwater recharge.

4.9 Mine Life Phases

A preliminary schedule for mine phases has been developed for mine and environmental management plans. The schedule considers the more significant thresholds to be as follows:

- **Startup:** Initial and preparatory development,
- **Project Development:** Construction of infrastructure necessary for managing water plus pre-stripping of soils to storage sites and overburden to the embryonic Engineered Land Forms,
- **Initial Surface Mining and Development of Underground Structures:** The first removal of gold ore at the Rise and Shine Pit, followed by the start of features such as the portal and access drift for the underground workings,
- **Initiation of Underground Mining,**
- **Initiation of Surface Mining at Satellite Pits, namely CIT, Srex east and Srex:** RAS Pit and RAS Underground would continue mining through these ore feed changes. Blending of ore would optimise ore processing and gold recovery.
- **Shut down of all Surface and Underground Mining,**
- **Active Closure:** Completing Engineered Land Form and Tailings Storage Facility, plus the deconstruction of the processing plant and other structures, and
- **Post-Closure:** Passive water management and monitoring at the EOML.

4.9.1 Details of Schedule

The phasing of these components of the BOGMP are specified further in Table 17. Table 18 includes a summary of the timing and duration of the main surface and underground mining centres, including the RAS Complex and satellite pits. Furthermore, illustrative and annotated satellite photograph maps of the BOGMP mining development and rehabilitation phases. The order and context of these maps are summarised as follows:

Startup	Figure 36
Project Development	Figure 37
RAS pit mining on its own	Figure 38
RAS pit plus RAS UG	Figure 39
RAS Pit plus RAS UG plus CIT Pit	Figure 40
RAS Pit plus RAS UG, plus Srex	Figure 41
RAS UG continues on its own.	Figure 42
Active Closure: All mining halted	Figure 43
Post-Closure: Periodic maintenance and monitoring	Figure 44

Table 17: Schedule of Mining Phases and the timing of each Phase through the planned Bendigo -Ophir Gold Project.

Month Range	Year Range	Mining Phase	Description of Phase	Figure No.
0 to 6	0 to 0.5	Startup	Pioneering / RAS Pre-Strip, Initial Jean Creek Silt Pond preparations, earthworks at process plant.	Figure 36
6 to 24	0.5 to 2	Project Development	Construction of process plant, TSF, Shepherds Creek Silt Pond, North Diversion Channel, Shepherds ELF preparations and early construction, Main haul road established (ROM – RAS – ELF/TSF), Commissioning, mining RAS pre-strip (Pre-strip ends month 19).	Figure 37
25 to 54	3 to 4.5	RAS pit mining on its own	Operations (Pit ore production in month 20. Process starts about month 22. UG Development months 48 – 54.	Figure 38
54 to 72	4.5 to 5	RAS pit with UG development	Operations (UG Ore production begins month 70 -)	
72 to 132	6 to 11	RAS pit plus RAS UG	Operations (UG Ore production months 70 to 150)	Figure 39
		RAS Pit plus RAS UG plus CIT Pit	Operations (CIT Pit mined months 102 to 114)	Figure 40
		RAS Pit plus RAS UG, plus CIT backfilled, plus Srex	Operations (Srex Pit mined months 145 onwards)	Figure 41
120 - 160	10 to 13.3	RAS UG continues on its own. Srex open pit feeds	Operations (all mining halted month 160)	Figure 42

Month Range	Year Range	Mining Phase	Description of Phase	Figure No.
160 - 372	11 to 31	***Active Closure***: All mining halted, active closure activities	Active closure of pits, TSF, and wider site, plus setup of active water treatment plant (option)	Figure 43
372 -	31 onwards	***Post-Closure***: Periodic maintenance of passive systems and monitoring	Passive treatment and maintenance	Figure 44

Abbreviations:

RAS	Rise and Shine
CIT	Come In Time
UG	Underground
ROM	Run Of Mine
ELF	Engineered Land Form
TSF	Tailings Storage Facility
“Pre-Strip”	Initial stripping of soils and overburden prior to mining

Table 18: Summary of schedule ore producing month range and duration of main elements

	Month Range	Year Range	Duration (months)
Rise and Shine Pit	24 - 132	2 - 11	108 (9 years)
Rise and Shine Underground	70 - 160	5.8 – 13.3	90 (7.5 years)
Come In Time Pit	102 – 114	8.5 – 9.5	12 (1 years)
Srex Pit	144 - 160	12 – 13.3	15 (1¼ years)

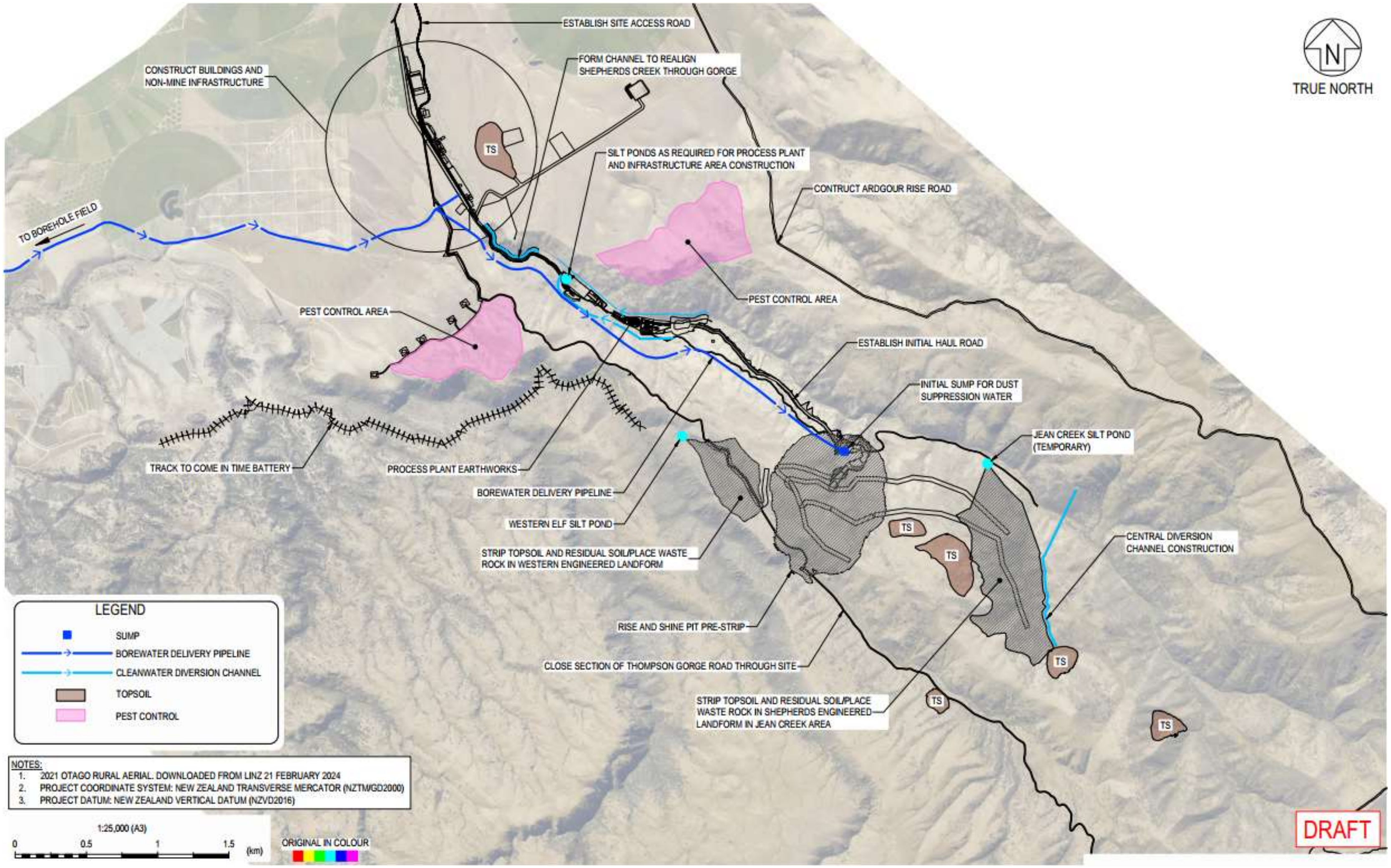

Figure 36: Start-Up, Month 0 – 6 activities: Pioneering / RAS Pre-Strip, Initial Jean Creek Silt Pond preparations, and earthworks at process plant.

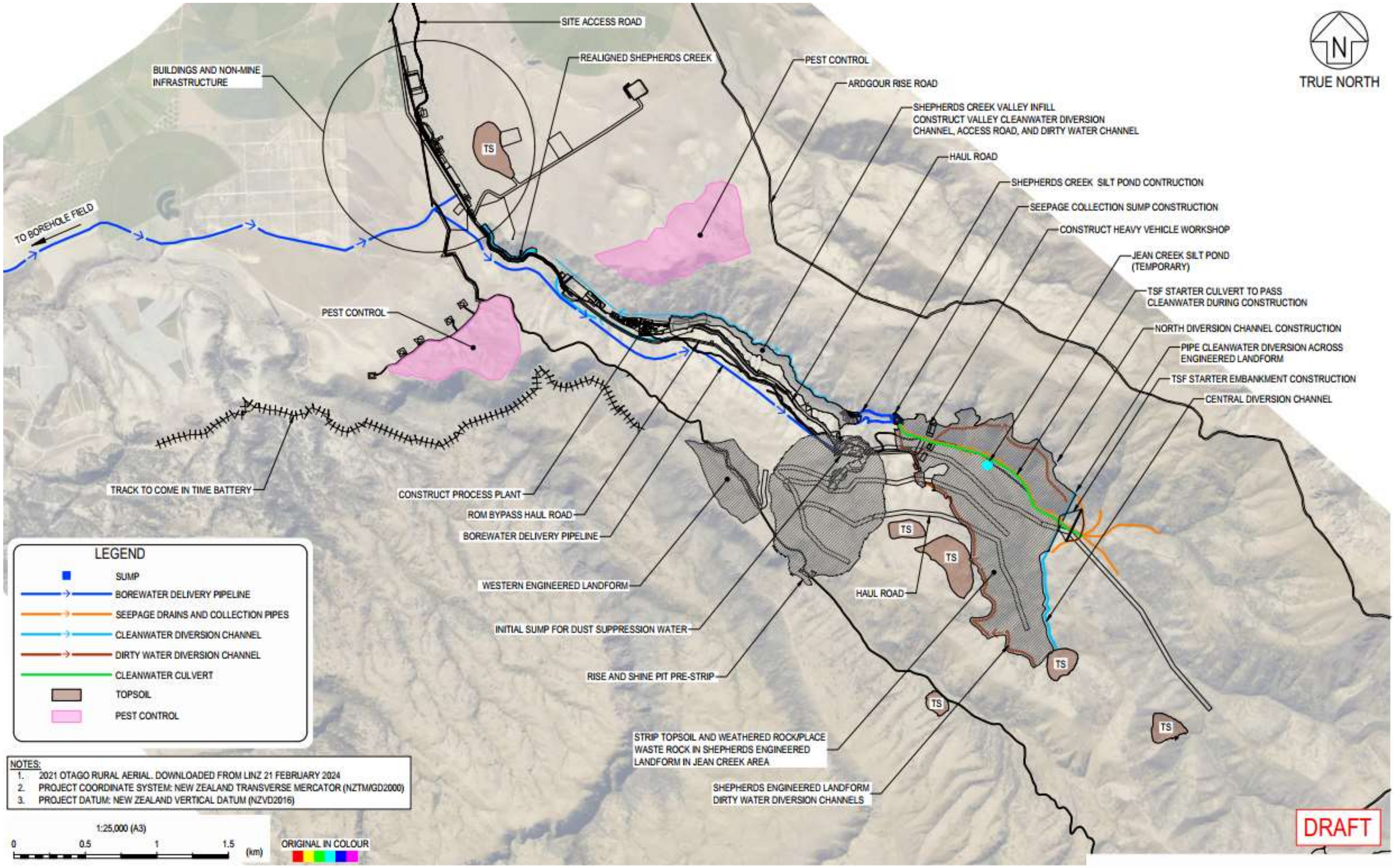

Figure 37: Project Development, Month 6 – 24 activities: Construction of Plant, TSF, Silt Pond, North Diversion Channel, Shepherds ELF prep. & early construction

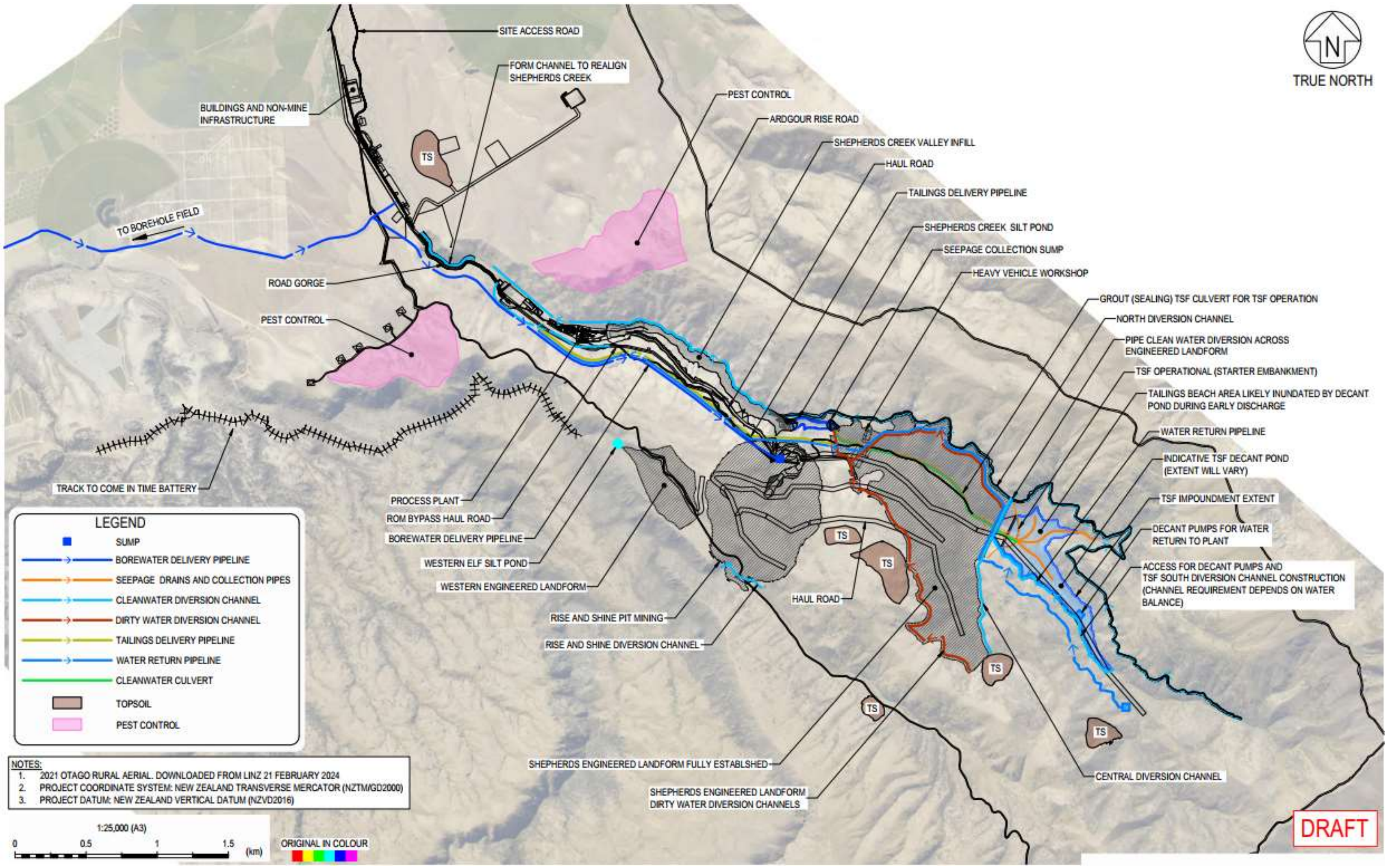

Figure 38: RAS Pit Mining, Month 25 – 54 activities: Surface mining producing and feeding processing, Underground development in months 48 – 54, without ore.

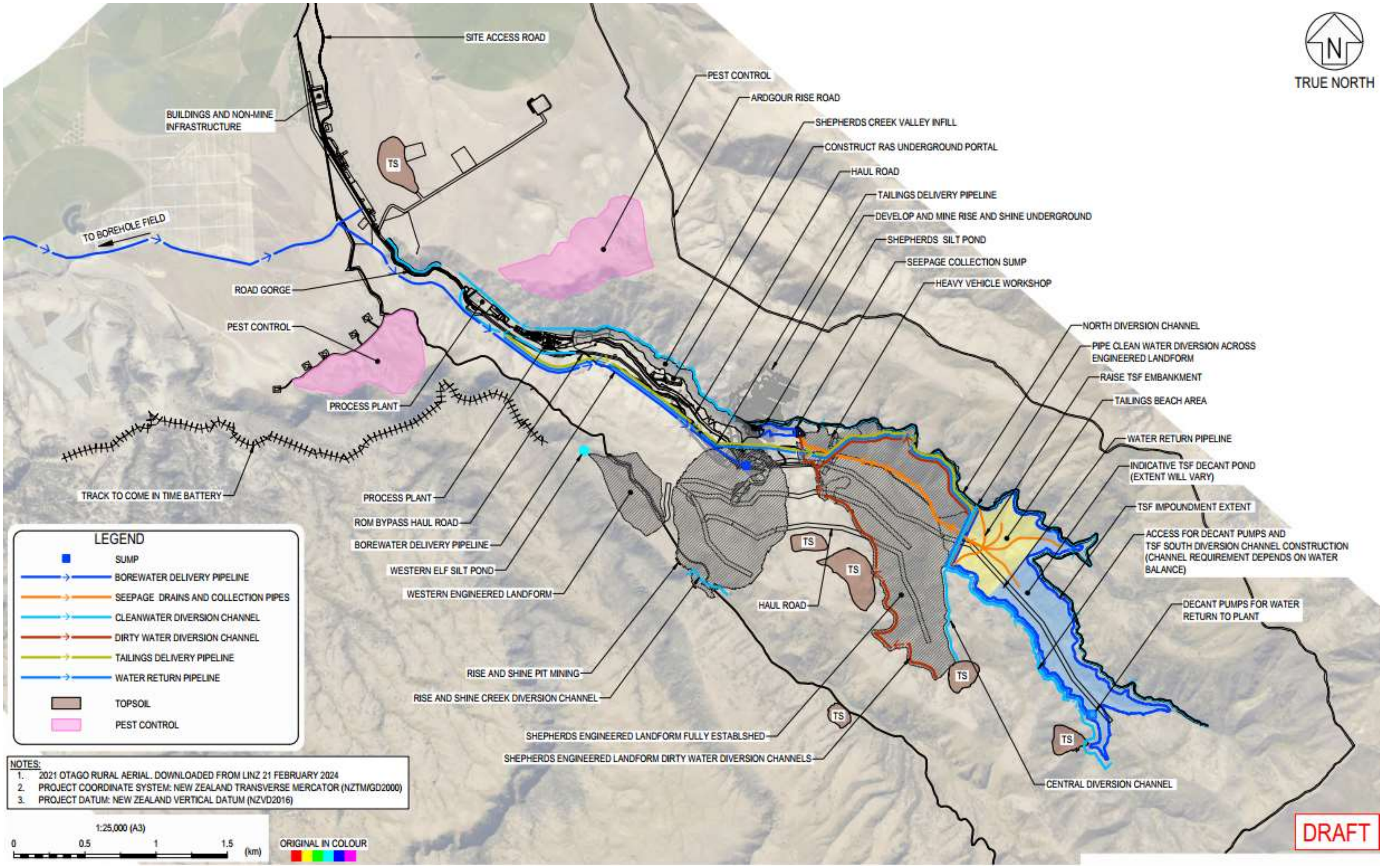

Figure 39: RAS Pit and RAS Underground Month 70 -150 activities (Note: Underground ore production from months 70 onwards)

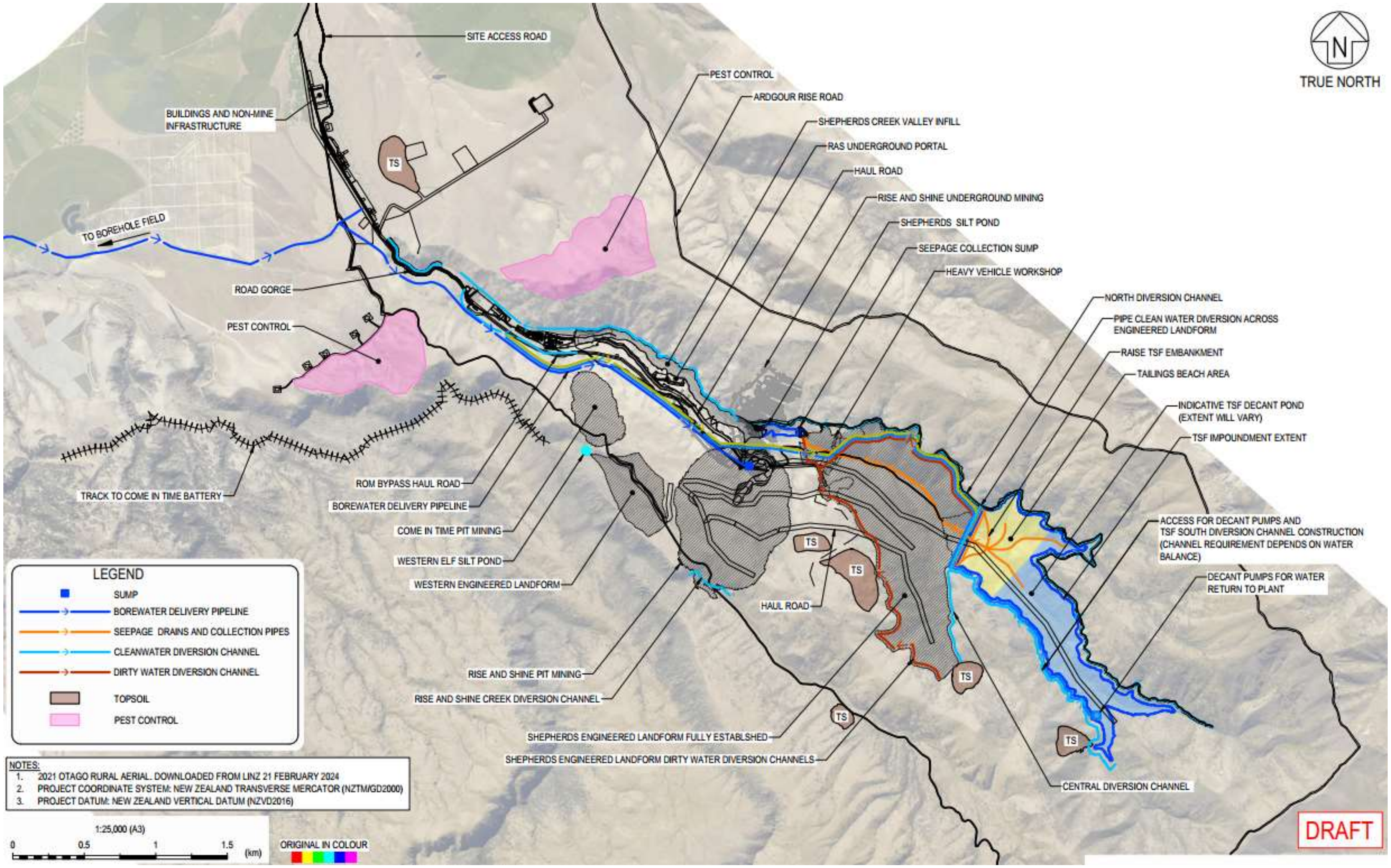

Figure 40: Come In Time (CIT) Pit surface mining in months 102 to 114

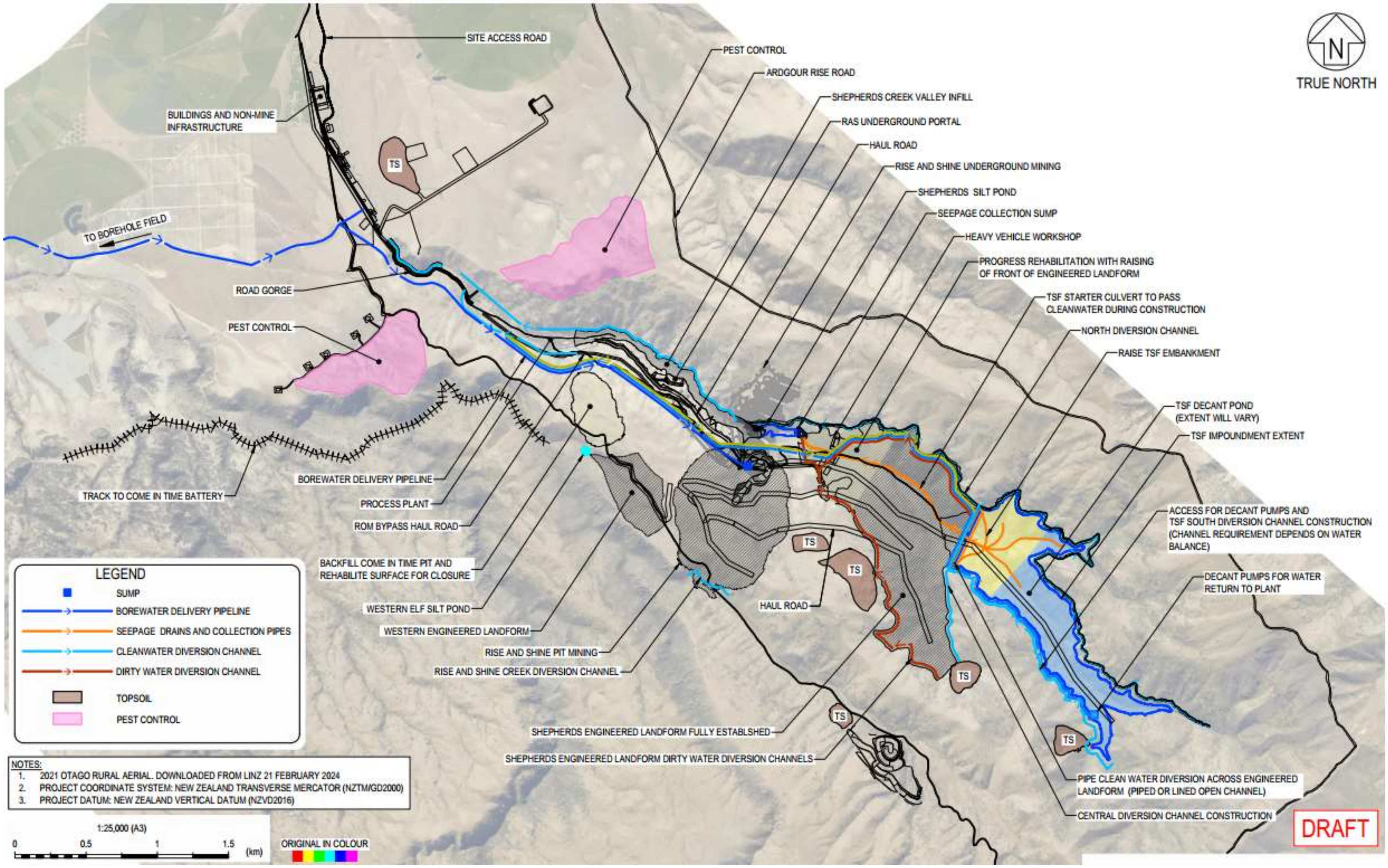

Figure 41: Srex Pit surface mining in months 145 - onwards

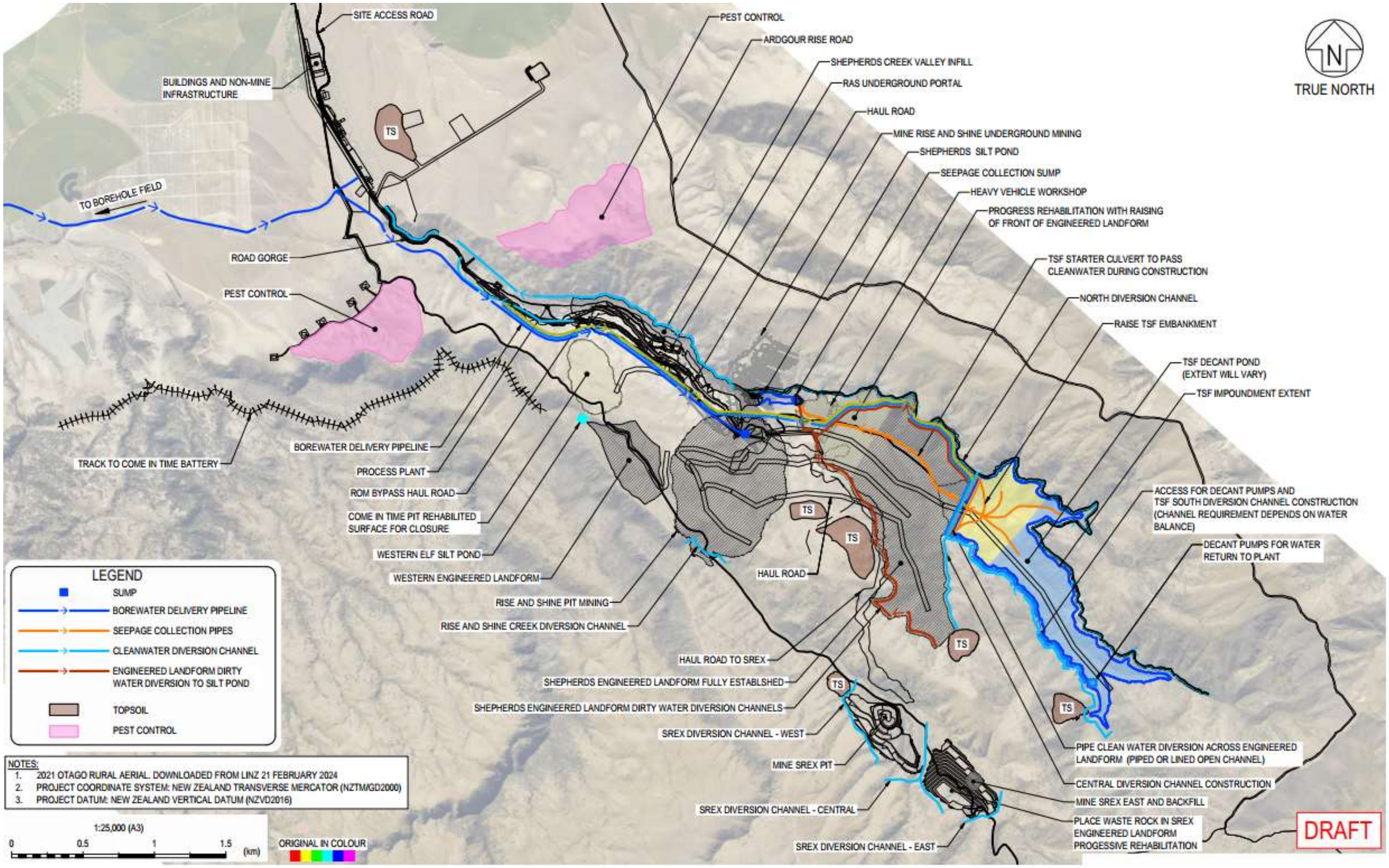

Figure 42: RAS UG continues on its own. Srex open pit feeds, months 120 – 160. All mining halts at month 160.

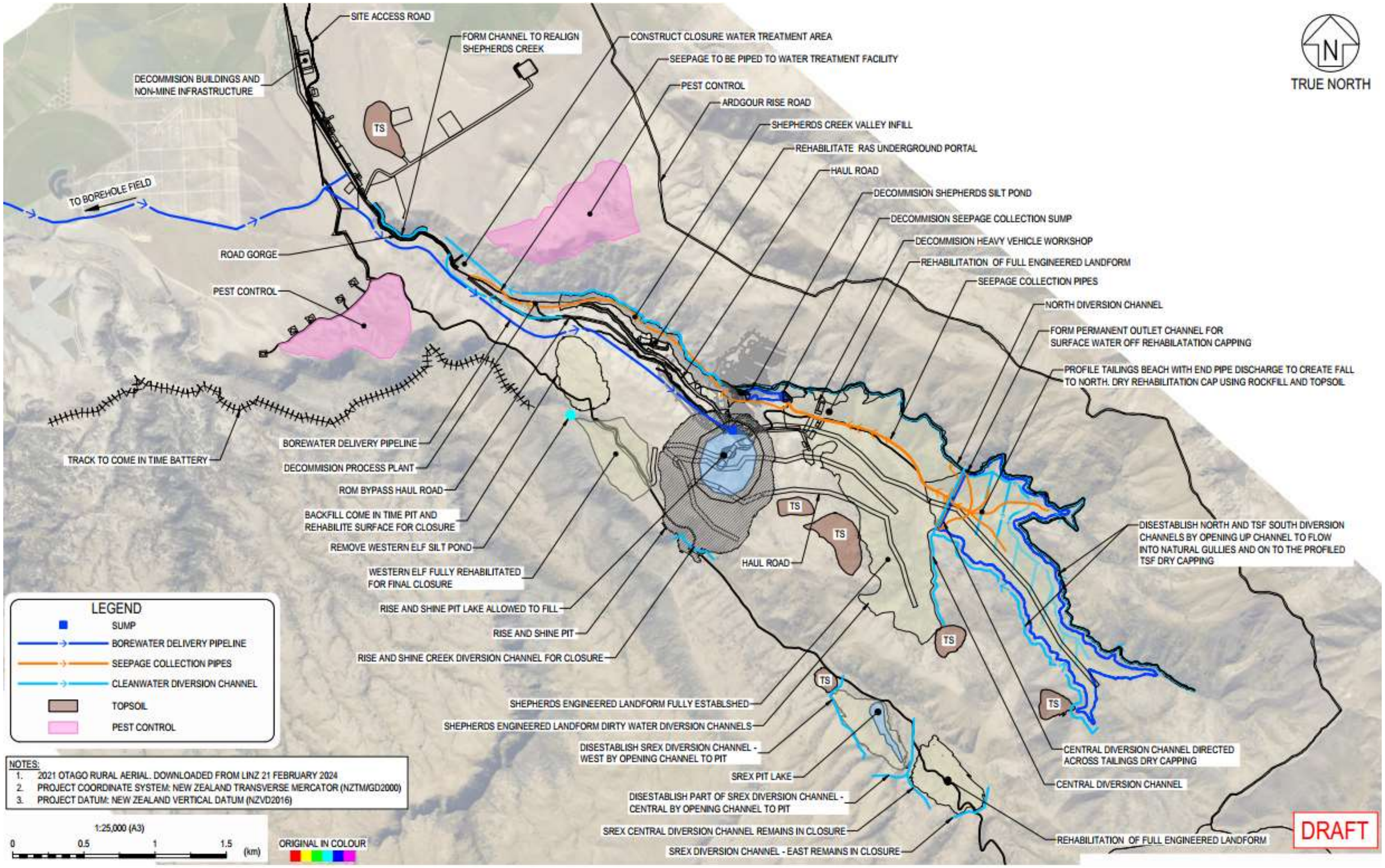

Figure 43: Active closure of pits, ELF, TSF, water management structures, and wider site months 160 – 372 (Years 11 – 31)

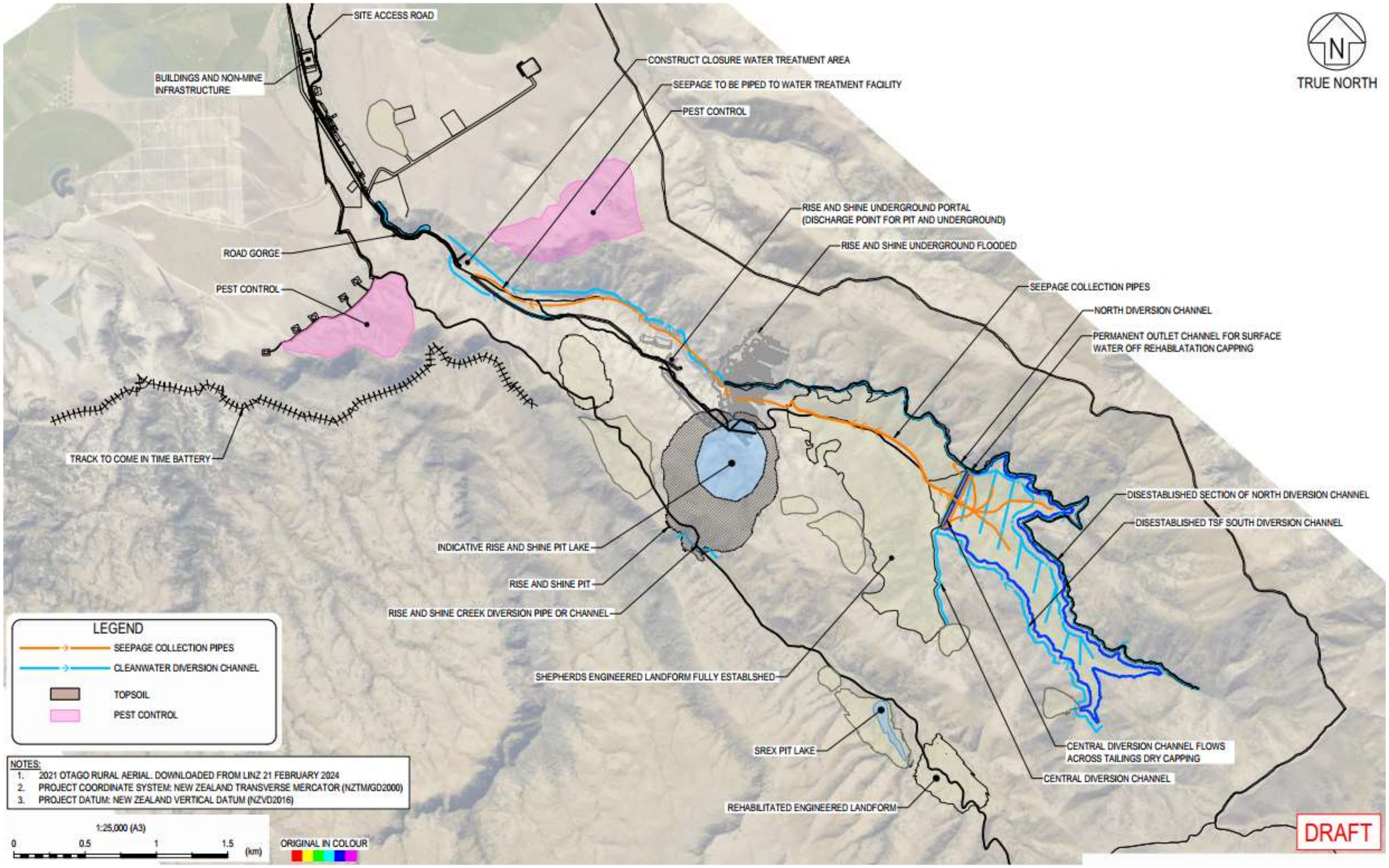

Figure 44: Post-Closure: Periodic maintenance of passive systems and monitoring, month 372 (Year 31 -) onwards

4.9.2 Operational Water Balance

For the period after most elements of the BOGMP mining are in place, i.e., RAS Pit, RAS Underground, ore processing plant, TSF and Shepherds ELF, an annual water balance is available. The water balance was undertaken by Mine Waste Management as part of the Water Management Treatment Report (Mine Waste Management, 2025a). It assumed a normal (i.e., mean annual) year of balance and was projected from modelling. The water balance included the principal, i.e., volumetrically significant water balance terms. The modelling employed a combination of mean flow exchanges obtained from independent modelling (e.g., MOFLOW groundwater model) or rainfall – runoff modelling using the simplified rational method, including annual runoff coefficients. Most of the runoff coefficients were based on measured exchanges and catchment areas of Macraes Mining Complex, East Otago. No make-up water supply is included in the balance, which results in the water balance showing a deficit of water on an annual basis. The primary water management nodes of the water management and treatment loop are as follow:

- Shepherds Seepage Collection Sump, which collects ELF seepage and feeds the Plant or TSF,
- Shepherds Silt Pond
- TSF that stores mine-impacted water, and
- RAS Pit and RAS Underground (UG) workings that receive groundwater inflow.

Table 19 details the resulting operational water balance in a normal (mean) annual period.

Table 19: Mean Annual Operational BOGMP Mine Site Water Balance (MWM, 2025a)

Water Make	***Normal Year (m^3)***	***Equivalent Rate (L/s)***
TSF Incident Rainfall	334,382	10.6
TSF gain from runoff from land	15,300	0.5
Shepherds ELF seepage	388,534	12.3
RAS Pit dewatering requirement	370,303	11.7
*RAS Pit Surface Water Inflow**	*212,623**	*6.7**
RAS UG dewatering requirement	599,594	19.0
Process Plant water surplus	192,501	6.1
Bore Water Importation	(Unknown)	(Unknown)
Total Water Make	1,900,614	60
Water Loss		
TSF Pond Evaporation	654,012	20.7
Water retained in tailings	525,000	16.6
Dust Suppression requirement	946,728	30.0
Cemented tailings paste water	94,673	3.0
Total Water Loss	2,220,413	70
Water Make minus **Water Loss**	-319,799	-10.1

Note: *The RAS Pit Surface Water Inflow in *italics* is a subset of the RAS pit dewatering requirement. Where the net water balance total is negative, the annual mine water balance would be in deficit, requiring the importation of bore water on an annual basis.

In typical operation, deficits would be made up with bore field water supply balancing. The water conservation protocol would dictate that mine-impacted water is used first before clean water from the bore field water supply is drawn from the supply reservoir. The temporal variations within any annual period would depart from the annual water balance detailed in Table 19, above. Further modelling of the operational period suggests that periodic overtopping of the Shepherds Silt Pond into the lower Shepherds Creek would occur.

The layout and volumetric proportions of the overtopping of the Shepherds Silt Pond are indicated in Figure 45, below. The pond would accept seepage from the Shepherds ELF toe drains *via* a seepage collection sump, which lies at the terminus of several toe drains, plus storm water running off the Shepherds ELF. The dead storage of 37,000 cubic metres would primarily be for the accommodation of silt and other fines. A decant tower underpass structure would allow the passing of pond water after settling. A floating intake connected to the underpass is an alternative option. At high inflows rates exceeding the underpass, a spillway would also be put in place to carry flood discharges past the impoundment of the Silt Dam. The live storage of the silt pond above the dead storage elevation would be 27,000 cubic metres, and use of this capacity would be made to store and transfer mine-impacted water (i.e., ELF toe seepage) to points of water utilisation, such as ore processing plant water feed, or to be stored in the TSF.

Modelling indicates that the exceedance of the 27,000 cubic metres of live storage (i.e., 100% of total storage capacity), would result in release of pond water into lower Shepherds Creek. Volumetrically, the amount of release past the silt pond would approximate 3% to 10% of the annual operation water balance at this node in the water management network. The hydrological implication is that no release would be made for 97% to 90% of the runoff and seepage accruing from upstream of the ELF, TSF footprints, and surrounding catchments. Flows from the northern, central and southern clean water diversions would continue to bypass the ELF and TSF water management perimeter and so enter lower Shepherds Creek at the discharge structures downstream of silt pond impoundment and thus sustain freshwater flows in the creek. Figure 45 also includes the seepage and stormwater nodes of the Shepherds ELF and the TSF.

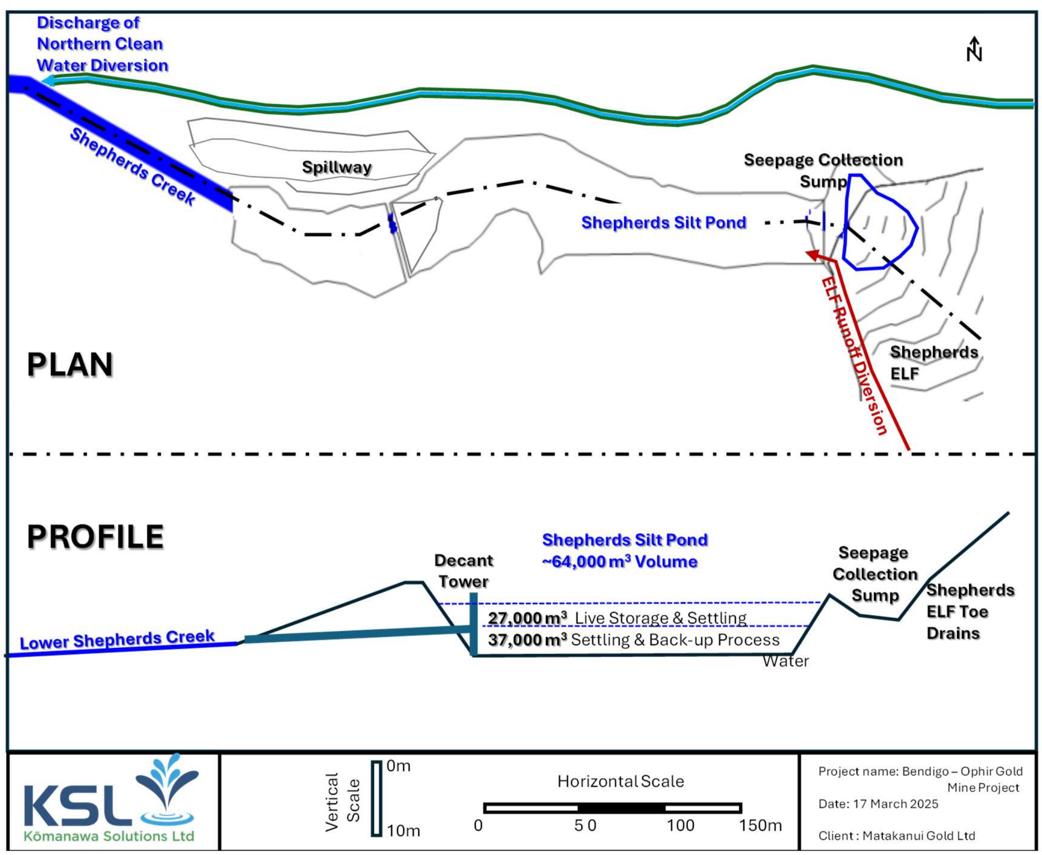

Figure 45: Schematic plan and profile of the Shepherds Silt Pond

5 Assessment of Surface Water Effects Arising from Proposed Activities

5.1 Background

Having outlined the nature and scale of proposed activities within the context of the existing environment, the task of this section of the document is to define and make predictions of consequent effects. The scope of environmental effects considered herein, include external effects on catchment flows related to mining activities or water management activities in response to these activities. Internal water balances pertinent to the mine site and waste or water management structures are dealt with and reported the Mine Waste Management water balances (Mine Waste Management, 2025b). Effects relating to surface water quality are primarily dealt with by Mine Waste Management in the context of this author's source term report (Mine Waste Management, 2025a). Consequential water quality effects are dealt with in ecotoxicology and freshwater ecology reports. Groundwater quality is dealt with in part, within the groundwater effects report (Rekker, 2025a). The opportunities to avoid, mitigate, and monitor potential effects are further examined in the next section (Section 6).

5.2 Operational Catchment Controls

5.2.1 Loss of Creek Flow

During the operation of the combined BOGMP mining complex, water management perimeters would be imposed surrounding the upper Shepherds Creek catchment and direct environs of the Srex Pits and ELF. After diverting clean water around the perimeters, the overall water management objective for the land area within the operational water management perimeters would be to maintain a near zero-discharge regime after Year 2 of operation. The implication of this policy for the Shepherds Creek catchment would be that the upper creek headwaters, excepting the springs and tributaries diverted around the management perimeter by the diversion channels (see Figure 38 - Figure 42), would cease to contribute surface water flows to the downstream Shepherd Creek. In other words, there would likely be a measurable decline in the creek flow monitored at flow monitoring site SC-01 during the operational phase with remaining and sustaining flow being provided largely by clean water diversions into lower Shepherds Creek.

Mine site water balance modelling of the operational phase suggests that minor discharges would be made into lower Shepherds Creek whenever the Shepherds Silt Pond reaches full capacity and water from the Shepherds ELF toe drains or intra-perimeter stormwater flows pass the silt pond impoundment (Mine Waste Management, 2025b) provides further information as to the operation and discharge volumes of the Shepherds Silt Pond. In the Srex mining zone, runoff from the Srex ELF would emerge into Rise and Shine Creek following detention to allow settling of sediment, particulates and amelioration in turbidity. A perimeter would be maintained around the Srex pit during operational activities towards the end of the mining period, with seepage water used in dust suppression and/or transferred to the TSF *via* pipeline. Three sets of clean water diversions would be established for the operational and post-closure phases at the Srex satellite mine:

- Diversion channel East around the ELF
- Diversion channel Central around the ELF and pit, and
- Diversion channel West around the Srex pit.

These Srex diversion channels are mapped in Figure 42 and would be established in the operational phase, immediately prior to mining activities being initiated at the satellite pit. Diversion channel west would be decommissioned following the cessation of ore extraction as part of initial active closure.

5.3 Active Closure and Post-Closure Period

5.3.1 Change in Hydrological Configuration and Runoff Properties

Following the halt on mining activities and rehabilitation of former mining terrains, the water management perimeter around the RAS pit, processing plant, Shepherds ELF and TSF would be decommissioned. The zero-discharge policy established in Year 2 of operations would be progressively relaxed in the Active Closure phase as former mining terrains were rehabilitated. Erosion and Sediment Control structures would be retained but softened, potentially incorporated into habitat restoration and Passive Treatment Systems (PTS).

Active closure, as outlined in (Mine Waste Management, 2025a) and (Mine Waste Management, 2025a) would involve progressive dissolution of the mine water management systems as follows:

TSF

- Subsurface seepage from base of TSF would continue to drain *via* a system of seepage collection pipes lain beneath the ELF and terminating at the Shepherds ELF toe drain area,
- A tailings beach profiled to create hydraulic gradient (fall) to the north,
- Installation of a rehabilitation capping using rockfill and topsoil,
- As drainage patterns over the capping materials are established, permanent outlet channels would be formed to conduct filled TSF runoff into the former northern diversion drain,
- Upon establishing the rehabilitated drainage patterns across the top of the TSF, the northern and central diversion channels abreast the TSF would be decommissioned, allowing a more natural drainage to join pre-existing gullies with the channel network across the dry capping layer.

Shepherds ELF

- Rehabilitation of the completed ELF land surface through recontouring and soil capping

Additional Mine Site Elements

- RAS underground workings would be allowed to fill with groundwater,
- RAS pit lake would be allowed to fill and merge with underground water at the pit wall penetration,
- The combined pit and underground water level would be allowed to rise to the sill elevation of the former access portal at an elevation of approximately 527 metres AMSL and the workings' drainage would establish with the portal as the point of discharge in the treatment plant, eventual PTS, or Shepherds Creek,
- Decommissioning the ore processing plant,
- Realigning Shepherds Creek from the previous channel alignment made to protect the plant,
- Rehabilitation of the realigned Shepherds creek course following the EOML and active closure,
- Rehabilitation of the completed CIT backfilled land surface through recontouring and soil capping,
- Provide drainage channel for the CIT seepage from the backfilled pit margin,
- Strengthen and soften the Rise and Shine Creek culvert across the back wall of the RAS pit, including detention bund and spillway structures,

However, the restored catchment lands and some aspects of the creek network would be materially altered in terms of runoff and downstream hydrology.

The primary sources of changed catchment hydrology include the following legacies of mining activities:

Rise and Shine Pit and Underground Transition to a pit lake with subsurface drainage

- The partially flooded Rise and Shine pit and underground with surrounding internally-draining catchment of 0.65 square kilometres,
  - New runoff coefficients for the emergent pit slopes would prevail,
  - A flow storage buffer would prevail in the pit lake and flooded workings.
- The former TSF in the Shepherds catchment would be resurfaced and contoured, but retain a somewhat artificial land surface and relief.

Come In Time backfilled and capped pit

- The former Come In Time pit in the Shepherds catchment would be backfilled with waste rock and capped, but a downhill groundwater spring at the interface with backfill and intact schist is likely to persist,

Srex Pit and Srex ELF

- The former Srex pit would be allowed to be, partially, naturally filled with water to form a small pit lake, pit slopes softened in rehabilitation but form a very small, indented catchment
- Surface water drainage would be returned to Rise and Shine Creek, and
- The Srex ELF would have an external profile and surface covering that differs from that prevailing land surface outside the mine site.

5.3.2 Water Treatment and Return to Natural Drainage Patterns

Following mine site closure and Active Closure, a transition from Active Water Treatment (AWT) to Passive Treatment Systems (PTS) would take place for the drainage domains with residual water quality detriments. These drainage domains are primarily –

- Shepherds ELF
- Western ELF
- Srex ELF
- Shepherds TSF
- RAS U/G Portal Discharge
- CIT Backfill spring(s)
- Srex pit

During the Active Closure Phase, once the project switches from internal water management for mine-impacted water (MIW) during operations to discharge of MIW from site after closure of the mine, water treatment would be selectively applied. The need for water treatment would result from the cessation of the ability to use water in the processing plant and dust suppression. Water treatment of several water streams would be required at a water treatment plant (WTP) for Active Water Treatment (AWT). GoldSim model results indicates that the WTP and AWT can eventually be replaced by a Passive Treatment System (PTS) within decades of mining cessation, which then defines the commencement of the Post Closure phase. Flow rates that require treatment are presented in

Table 20.

Table 20: Closure Flow Rates Requiring Water Treatment (Mine Waste Management, 2025b)

	Active Closure		**Post-Closure**	
Mine Domain	**Average Flow Rate (L/s)**	**OoM Design Criteria Flow Rate (L/s)**	**PTS Flow Rate (L/s)**	**Notes**
Shepherds ELF into Shepherds Ck	7.4	8	8	40% net precipitation transiting ELF into lower Shepherds Creek
Shepherds TSF into Shepherds Ck	13.4	15	5	Expected to be approximately 15 L/s, decreasing to 4 L/s after 5 years.
RAS U/G Portal into Shepherds Ck	6.0	_	7	Flow from the RAS Underground (U/G) is not expected for 50 – 60 year post closure due to the slow rate of pit lake filling

	Active Closure		Post-Closure	
Mine Domain	**Average Flow Rate (L/s)**	**OoM Design Criteria Flow Rate (L/s)**	**PTS Flow Rate (L/s)**	**Notes**
CIT Pit Backfill into Shepherds Ck	1.9	2	2	Emerging as seepage, stable rate of flow.
Srex ELF into Rise and Shine Ck	1.0	1	1	40% net precipitation transiting ELF
Srex Pit into Rise and Shine Ck	7.4	_	8	It is assumed this would require treatment due to lack of dilution for concentrations entering surface water.

Note: OoM = Order of Magnitude in relation to design criteria.

These rates of flow would be released from the AWT or PTS into their respective creeks and resume flow into the respective downstream catchments (Lindis or Bendigo). In the case of the PTS passive systems, the treatment would feature retention in a pond or intentional treatment wetland with the associated buffering of flow rate. Additionally, an extended hiatus of 50 – 60 years would be expected before the RAS pit lake and underground workings would connect to the surface water system, detaining an average of 6 litres per second from Shepherds Creek that would go into the filling of the pit lake to an elevation of 490 metres AMSL, or slightly higher.

5.3.3 Net Post Closure Changes to Creek Hydrology

Changes to the hydrology from the pre-mining baseline conditions to the Post Closure conditions for Shepherds and Rise and Shine creeks are list in Table 21. The hydrological statistics were modelled within the GoldSim simulation package (Mine Waste Management, 2025b).

Table 21: Summary of Modelled Pre-Mining and Post Closure Hydrological Statistics for Affected Creeks

	Shepherds Creek @SC-01		Rise and Shine Creek @RS-03*	
Hydrological Statistic	**Baseline**	**Post-Closure**	**Baseline**	**Post-Closure**
Unit	***(L/s)***	***(L/s)***	***(L/s)***	***(L/s)***
Mean	18.3	29.1	12.1	18.6
Median	12.1	23	8	14
$MALF_{-7d}$	2	12.5	1.3	5.5
1-in-5 Year Low Flow	1.3	10.5	0.9	4.9

Note: * RS-03 is a water quality monitoring site on Clearwater Creek, downstream of Rise and Shine Creek confluence.

Table 21 reveals an increase in all hydrological statistics in both creeks from the pre-mining to Post Closure states. Table 22 reports the distinct increases in both mean and median creek flows, plus the equivalent increase in the annual runoff coefficients for the Shepherds and Rise and Shine creek catchments.

Table 22: Percentage Increase in Mean and Median Flows, and Runoff Coefficients

	Shepherds Creek @SC-01	Rise & Shine / Clearwater @RS-01
	(% Increase)	***(% Increase)***

	Shepherds Creek @SC-01	Rise & Shine / Clearwater @RS-01
Mean	37.1%	34.9%
Median	47.4%	42.9%

Note: Mean annual rainfall set at 510 mm/year in the calculation of runoff coefficients.

In plain terms, the proportion of rain falling over the mine site that generates runoff increases as a result of accumulated changes to the restored and rehabilitated land hydrologic characteristics following closure. This arises partly from the change in condition of the surfaces that mediate the split between water lost to evapotranspiration / evaporation and water generating runoff / infiltration in the upstream catchment lands. In the pre-mining state, upland soils and weathered schist regolith underlain by competent schist rock tends to prevent the penetration of soil-moisture beyond the reach of evaporation or evapotranspiration unless immediate weather conditions favour runoff. As a result, much of the rain is evaporated or transpires in the same day that it falls. Very little soil-moisture or lateral soil drainage may penetrate into the subsoil due to prevalence of rejected recharge tendencies of the upper catchment.

In the post closure state, soil-moisture is able to readily penetrate disturbed post-mining surfaces, particularly those of the capped Shepherds and Srex ELFs, backfilled CIT pit, capped TSF, and former haul roads. The water-filled mine voids, especially the RAS pit lake, provide substantial flow buffering within the level fluctuation range of the void. The Post Closure RAS pit lake would absorb 30,000 cubic metres for each metre of lake water level increase, which equates to 3.3% of annual Shepherds Creek catchment yield. These proportions underline the significant flow buffering intrinsically that would be added to the drainage network in the Post Closure period. The hydraulic friction losses (i.e., 'roughness') of the subsurface hydraulic connection between the pit lake and point of discharge would result in increases in lake storage being yielded to Shepherds Creek in a delayed manner.

5.4 Section Summary

The surface water hydrological system would be affected in terms of flows and volumes transiting the creeks across the BOGMP mine site:

- Shepherds Creek would experience the following overlapping series of hydrological effects –
  - Retention of surface runoff within interim silt ponds in the pioneering phase,
  - Retention of toe drainage and ELF surface runoff within Shepherds Silt Pond in the operational phase, including
    - Taking of water for the ore processing plant, or
    - Transfer and retention of mine-impacted water in the TSF ponding.
  - Groundwater-mediated depletion of Shepherds Creek as it passes the RAS and CIT pits at rates peaking at six (6) litres per second of depletion *via* the hard rock groundwater system,
  - The RAS pit and pit lake would form an internally draining basin of 70 hectares in extent and approximately 6L/s potential contribution to Shepherds Creek, which would also be removed from the effective Shepherds catchment until the underground portal commences discharge to surface, potentially *via* water treatment facilities,
  - A system of clean water drains and diversion channels, most of which have low gradient and hug the land contour, would conduct surface water that need not enter the mine site around disturbed areas and serve to maintain flow in the lower creek, particularly during the operational and active closure phases of mine life, and
  - Following the full restoration of flow connection across the former mine site in the post closure period, the lower creek should experience higher flow rates across all hydrological statistics due to enhanced catchment flow recruitment in the presence of more permeable substrate

and more porous flow reservoirs provided by restored mine waste deposits such as former ELFs and the TSF, as well as the RAS pit lake.

- Rise and Shine Creek and the downstream Bendigo Creek catchment would experience the following overlapping series of hydrological effects –
    - Rise and Shine Creek is affected by two main structures:
        - Crossing of the Creek by the south western extension of RAS pit, which is culverted from one side of the pit to the downstream side to maintain continuity,
        - The excavation of SRX pit and construction of SRX ELF in the upper catchment.
    - A system of clean water diversions would be instituted to route upstream tributary creek water around the SRX pit and SRX ELF,
    - If indicated by monitoring of SRX ELF runoff and seepage water quality, the mine-impacted water would be diverted to the TSF,
    - Groundwater-mediated depletion of the Creek as it passes the SRX pit at rates peaking at 17 litres per second through the hard rock groundwater system during operations,
    - At the highest rate of depletion effect, the total flow of the adjacent Rise and Shine creek might be drawn towards the SRX pit, on occasion,
    - Clean water diversions upstream of the SRX pit and ELF would serve to provide maintenance of creek flow downstream of the SRX mine site,
    - The lower creek at the RAS pit would retain all remaining flow other than flood flows that would not be capable of being carried by the culvert, and
    - Post closure creek flow would be fully restored with the exception that the lower creek should experience higher flow rates across all statistics due to enhanced catchment flow recruitment in the presence of more permeable substrate and porous flow reservoirs provided by restored mine waste deposits such as former the ELFs.
- The Clutha River / Mata Au would be affected by groundwater related depletion in response to bore field pumping for the MGL mine site clean water requirements during the operation phase of the BOGMP-
    - Up to 64% of the long-term bore field pumping rate of 110 L/s (i.e., 2,220,134 cubic metres per annum) could be depleted from river flow after 365 days of pumping at 110 L/s (i.e., 3,468,960 cubic metres per annum), which is a substantial over-estimated of the expected operational annual volume of groundwater take (see Table 19), and
    - With a mean rate of 271,100 litres per second, the Clutha River / Mata Au adjacent to the Bendigo Aquifer would have a contrast in scale to make river flow invulnerable to the maximum rate of projected rate of groundwater depletion associated with the BOGMP.
- The period within which it is projected that the surface water hydrological systems would be most tangibly affected by a decline in flow rate would be as follows:
    - The late operational phase when the dual depleting effects of groundwater-mediated depletion and retention and even use of catchment water would be at the higher rates, and
    - The active closure period and up until the resumption of outflow from the RAS pit lake discharge, when depletion and retention by post-mining structures would be waning but still active.
- In the middle post closure phase following 50 - 60 years of pit lake filling, it is projected that surface flow rates across the flow duration curve would be increased between 35% and 47% of baseline rate.
- The valley-bottom alluvial groundwater systems at the base of the Shepherds Creek and Bendigo Creek receive all net creek flows before these are passed to the respective main stem rivers as groundwater flow and seepage.
- Operational flow interruptions due to dewatering related depletion and retention of runoff would curtail but not interrupt the surface water recharge of the alluvial aquifers, however all alluvial aquifers

have multiple and independent sources of recharge that would serve to rebalance the associated water balance.

- Active closure and post closure restoration of creek hydrology would involve the return of full and enhanced creek flows, also bearing novel dissolved load of sulphate, total nitrogen and other solutes that would disperse within the valley floor groundwater systems.

6 Steps to Avoid, Mitigate and Monitor Potential Effects

6.1 Background

The Resource Management Act 1991 does not merely require the assessment of the potential effects of a proposed activity and predicting the extent or intensity of those impacts. There is a further requirement to evaluate the ability to avoid, remedy, minimise, mitigate, offset and/or compensate those effects. The purpose of this section is to set out the further evaluation of surface water-related effects and indicate the proposals for such environmental management.

6.2 Mine Site Groundwater-Mediated Depletion and Catchment Flow Retention

Summary of Anticipated Effects per Phase

Operational Mining Phase (Month 1– 160, Year 1 – 13.3)

- **Shepherds Creek** would experience the following overlapping series of hydrological effects –
    - Retention of surface runoff within interim silt ponds in the pioneering phase,
    - Retention of stormwater and toe drainage and ELF surface runoff within Shepherds Silt Pond in the operational phase
    - Groundwater-mediated depletion of Shepherds Creek as it passes the RAS and CIT pits at rates peaking at 3.5 litres per second.
    - The RAS pit and pit lake would form an internally draining basin of 70 hectares in extent and approximately 6 litres per second potential contribution to Shepherds Creek.
- **Rise and Shine Creek** and the downstream Bendigo Creek catchment would experience the following overlapping series of hydrological effects –
    - Rise and Shine Creek is affected by two main structures:
        - Crossing of the Creek by the south western extension of RAS pit, which is culverted from one side of the pit to the downstream side to maintain continuity,
        - The excavation of SRX pit and construction of SRX ELF in the upper catchment.
    - A system of clean water diversions would be instituted to route upstream tributary creek water around the SRX pit and SRX ELF for the restricted period of operations at the SRX mine site.
    - Groundwater-mediated depletion of the Creek as it passes the SRX pit at rates peaking at 17 litres per second through the hard rock groundwater system during operations,
    - At the highest rate of depletion effect, the total flow of the adjacent Rise and Shine creek might be drawn towards the SRX pit, on occasion.

Wind Down & Active Closure Phase (Month 160 – 372, Year 13.3 – 31)

- **Shepherds Creek** would experience the following overlapping series of hydrological effects –
    - The RAS pit and pit lake would form an internally draining basin of 70 hectares in extent and approximately 6 litres per second potential contribution to Shepherds Creek, which would also be removed from the effective Shepherds catchment until the underground portal commences discharge to surface, potentially *via* water treatment facilities.
    - A system of clean water drains and diversion channels, most of which have low gradient and hug the land contour, would conduct surface water that need not enter the mine site around disturbed areas and serve to maintain flow in the lower creek.
- **Rise and Shine Creek**
    - The lower creek at the RAS pit would retain all remaining flow other than flood flows that would not be capable of being carried by the culvert.

Post-Closure Phase (Month 372 – onwards, Year 31 – onwards)

In the post-closure phase of the BOGMP, the rise in groundwater saturation levels and shut down of dewatering in the RAS Pit plus Underground would result in water flowing from the Pit through the higher elevation Underground stopes and discharging at the Underground mine portal.

- **Shepherds Creek** would experience the following overlapping series of hydrological effects –
    - Following the full restoration of flow connection across the former mine site in the post closure period the lower creek should experience higher flow rates across all hydrological statistics due to enhanced catchment flow recruitment in the presence of more permeable substrate and more porous flow reservoirs provided by restored mine waste deposits such as former ELFs and the TSF, as well as the RAS pit lake.
- **Rise and Shine Creek** and the downstream Bendigo Creek catchment would experience the following overlapping series of hydrological effects –
    - Post closure creek flow would be fully restored with the exception that the lower creek should experience higher flow rates across all statistics due to enhanced catchment flow recruitment in the presence of more permeable substrate and porous flow reservoirs provided by restored mine waste deposits such as former the ELFs.

6.2.1 Avoid or Minimise Effects

The principal method proposed for the avoidance and minimisation of the loss of creek flows would be the planned diversion channels that maintain the hydrological function of the wider upstream creek catchment by preventing its entanglement in quantitive or water quality deterioration relating to mining activities. All proposed mining areas have clean water diversions, although such diversions are minimal in extent for the CIT pit. It is anticipated that the northern and central diversion channels would provide for the maintenance of a significant portion of the original Shepherds Creek flow downstream of the Shepherds Silt Pond.

Following the establishment of restored and rehabilitated hydrological function of the former mine site, the flow rates and water resources are projected to be enhanced, resulting in greater downstream flows.

6.2.2 Other Mitigation & Monitoring of Effects

The principal effects of the cessation of RAS and Srex dewatering pumping is the progressive filling of the workings, forming a pit lake. The treatment of mine-impacted water of the net outflow of pit and underground zones would be required once the pit lake fills to the point of exceeding the 527 metres AMSL portal elevation. Water treatment would either be active or passive depending on the comparison of discharge standards or targets, against the results of monitoring of water quality in the former workings. Active treatment of water would require power supply, reagents and regular interventions and management, whereas passive treatment would have lower levels of intervention. Passive treatment would be more likely to employ self-sustaining biogeochemical processes such as reed-beds or other filter zones (Mine Waste Management, 2025b).

The water levels and water quality of the pit lake plus surrounding groundwater would be subject to a comprehensive monitoring plan that provides information on groundwater level rebound and the resulting impacts on water quality and ultimate hydrological state. There would also be tie-ins with the water quality management and/or geotechnical pit wall stability monitoring for the closed surface pit and underground.

Flow monitoring at SC-01 would be maintained throughout the life of the mine and beyond into the active closure period. The current baseline creek flow monitoring sites on Jean Creek and Shepherds Creek at these creeks' confluence (JC-01 and SC-03, respectively) would be engulfed by the developing ELF and Shepherds Silt Pond. Before this would occur, it is recommended that a replacement creek flow monitoring site be established downstream of the Shepherds Silt Pond and the outlet of the northern freshwater diversion drain to measure the flow rate of the middle reaches of Shepherds Creek.

Photographic monitoring surveys should also be undertaken in conjunction with temperature logging in a longitudinal transect of the Shepherds Creek bed to monitor the responses to the cessation of irrigation take and depletion / retention of creek flow rates in the late operational and Active Closure phases of mining activities.

6.3 Bore Field Pumping

6.3.1 Avoid or Minimise Effects

Most groundwater take effects are directly proportional to the instantaneous or median pumping rate, plus the long-term volume across a seasonal cycle. Short-term rates of water take from a bore field are more influential in short-distance drawdown effects. Seasonal or annual abstraction volumes are more influential in the bore field's effect on in avoiding / minimising further-afield groundwater values such as aquifer overdraught.

6.3.1.1 Water Conservation

Water conservation is a targeted strategy to minimise the requirement to draw groundwater from the bore field. The Water Management Plan would set out the criteria for projecting the dust suppression on the following basis:

- Moving average soil moisture status,
- Frequency of suppression water application and application rate (mm/application),
- Relevant plant factor,
- Extent of land area requiring dust suppression and practically available for application,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water.

Similarly, the water requirement from the ore processing plant would be variable. The Water Management Plan would set out the criteria for projecting the ore processing plant water requirements on the following basis:

- The scheduled throughput of the ore processing plant,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water from the bore field.

Sources of mine water suitable for diversion into the ore processing make-up water, include groundwater pumping from the Rise and Shine pit, stormwater collected within the processing plant perimeter, or decant water from the base of the ELF. The remaining water demands associated with the mining complex would be subject to water conservation measures. Such measures may include reducing water consumption while meeting the same demand by installing high water use efficient appliances and practices.

6.3.1.2 Mine Water Substitution

As outlined above, waste streams of mine water and mining affected stormwater at appropriate water quality norms would be deployed in augmenting mining complex water requirements.

The principal substitutions of water with mine-impacted water would include –

- Dust suppression water,
- Ore processing make-up water,
- Watering-efficient uses of water.

The sources of mine-impacted water would include –

- Pit dewatering pumping,
- Underground mine water surplus,
- Tailing Storage Facility decant water,
- Collected storm water.

Protocols would be developed to allow appropriate substitution of water source to water requirement, as set out above. The annualised operational mine site water balance outlined in section 0 and Table 19 of average rates of water use and climate conditions provide a basis for appreciating that water substitution could significantly reduce the requirement for make-up water from the Bendigo Aquifer bore field compared to the consent envelope.

6.3.2 Monitor Effects (Water Level and Flow)

Monitoring of the following surface hydrological phenomena would be maintained –

- Shepherds Creek catchment <u>Flow</u> at
  - Operational Shepherds Seepage Collection Pond,
  - Operational Shepherds Silt Pond,
  - Operational Shepherds Northern, Central and Southern diversion drains,
  - Active closure active treatment plant discharge,
  - Post closure SC-02,
  - Post closure former access drift portal, and
  - SC-01, throughout pioneering, operations, active closure and post closure.
- Rise and Shine Creek <u>flow</u> at
  - RS-02
  - RS-01
  - RS-03
- Pit <u>water level</u> at
  - RAS Pit
  - RAS Underground (Crown Pillar Stope)
  - CIT Pit
  - SRX Pit

6.3.3 Monitor Natural Environment

Some aspects of the natural environment require monitoring alongside effect monitoring. The rationale for such natural environment monitoring is that a number of natural hydrological phenomena have a bearing on the magnitude of potential effects. The best example of such natural hydrological phenomena are climate phenomena. Accordingly, it is recommended that existing rainfall gauge monitoring at Lake Clearwater, CIT pit edge and SRX pit edge.

6.4 Section Summary

The surface water hydrological system would be affected in terms of flows and volumes transiting the creeks across the BOGMP mine site:

- Shepherds Creek would experience the following overlapping series of hydrological effects, including depletion of flow during operations. The tendency for diminished flow rates would be partially mitigated by –
  - A system of clean water drains and diversion channels, most of which have low gradient and hug the land contour, would conduct surface water that need not enter the mine site disturbed areas, to maintain flow in the lower creek.
- The hydrology Rise and Shine Creek and the downstream Bendigo Creek catchment would experience creek bed interruption at the RAS pit and groundwater-mediated depletion as the existing Rise and Shine Creek main stem passes the deepest dewatering sump in the SRX pit. Mitigation would take the following forms –

- A system of clean water diversions would be instituted to route upstream tributary creek water around the SRX pit and SRX ELF, and
    - Crossing of the Creek by the south western extension of RAS pit, which is culverted from one side of the pit to the downstream side to maintain continuity, and
    - The excess flood flows of the Rise and Shine Creek catchment upstream of RAS culvert crossing would be cast into the RAS pit and be settled in the RAS Pit lake during operational, active closure and post closure.
- The Clutha River / Mata Au groundwater related depletion would be mitigated by water conservation and water use minimisation measures that reduce the reliance needing to be made on the BOGMP bore field.
- Monitoring of the following surface hydrological phenomena would be maintained –
    - Shepherds Creek catchment <u>Flow</u> at
        - Operational Shepherds Seepage Collection Pond,
        - Operational Shepherds Silt Pond,
        - Operational Shepherds Northern, Central and Southern diversion drains,
        - Active closure active treatment plant discharge,
        - Post closure SC-02,
        - Post closure former access drift portal, and
        - SC-01, throughout pioneering, operations, active closure and post closure.
    - Rise and Shine Creek <u>flow</u> at
        - RS-02
        - RS-01
        - RS-03
    - Pit <u>water level</u> at
        - RAS Pit
        - RAS Underground (Crown Pillar Stope)
        - CIT Pit
        - SRX Pit

7 Conclusions

The following concluding observations and concluding statements have been provided as a summary of the existing hydrological environment and surface water hydrological assessment.

1. Matakanui Gold Ltd propose developing a multi-component mining complex in the foothills to the Dunstan Mountains, near Bendigo. The complex would be comprised of the following elements:
    a. The Rise and Shine (RAS) pit to surface mine overburden and gold ore,
    b. The RAS Underground Workings to follow the gold ore to greater depth than for surface mining,
    c. The Come In Time Pit (CIT) to surface mine overburden and gold ore,
    d. The Srex and Srex East Pits (SRX and SRE) to surface mine overburden and gold ore,
    e. The ore processing plant,
    f. A Tailings Storage Facility (TSF) to receive post-processing tailings, mainly of surface mining,
    g. The Shepherds and Western Engineered Land Forms (ELFs) to receive waste rock from overburden,
    h. The Bendigo Aquifer water supply to provide piped groundwater for mining needs, and
    i. Various ancillary silt dams, soil stockpiles, Run Of Mine (ROM) stockpiles, toe drains, diversion drains and other pumped or unpumped water transfer structures are included in the mine plans.
2. The mine site sits across the upper Shepherds (with RAS and CIT deposits), and Rise and Shine (with the SRX deposit) creek catchments, and would affect Shepherds Creek during almost the entirety of the 13.3 year period of operational mining. Conversely, the flow of Rise and Shine Creek would be largely unaffected until Month 144 (Year 12) of the mine schedule.

3. The RAS pit at its peak would induce the inflow of groundwater at rates between 5 and 9 litres per second into the pit sump collection point, primarily from the hard rock groundwater compartment but including a portion reporting to the pit dewatering sump from the surrounding shallow regolith veneer and slopes draining into the pit.

4. As outlined in the groundwater assessment report, dewatering of the RAS pit at its peak would induce the loss of between 0.5 and 3.5 litres per second from Shepherds Creek *via* the hard rock groundwater system within the fractured schist rock. As outlined in the Mine Waste Management water balance term report, pit dewatering would create an internally draining basin around the core of the pit yielding approximately 5 L/s from hard rock plus 6.7 L/s from incident rainfall and surrounding catchment drainage. Such sump yields would initially be sent to the TSF for evaporation or reuse, and would later following closure, be excluded from catchment creek flows for up to 60 – 70 years until the rebound of the RAS pit lake level allowing its outflow *via* the underground portal.

5. The construction of the Tailings Storage Facility (TSF) would enclose an area of 65.5 hectares of the upper Shepherds Creek catchment, with the remaining upper catchment excluded by the Northern, Central and Southern diversion drains conducting these catchment yields beyond the Shepherds Silt Pond into the lower creek. Being behind an engineered impoundment and further buttressed by the Shepherds ELF in later years of mine operations, the TSF would allow the storage of mine-impacted water for later reuse in the ore processing plant or dust suppression water spreading.

6. The construction of the Shepherds Engineered Landform (ELF) is designed to receive the non-ore surface mining waste rock plus tunnelling waste rock and progressively build up a mass of layered lifts to limit the ingress of atmospheric oxygen and pore water. However, the footprint of the ELF interrupted the previous (Shepherds Creek South Branch and Jeans Creek) catchment drainage, with the exception of the drainage that could be maintained through the use of clean water diversion drains and some stormwater reporting to the Shepherds Silt Pond.

7. The Srex East and then Srex pits extended into ore at relatively shallow depths up to 50 metres below the original ground level. The Srex pit would induce higher seepage rates of up to 23 litres per second due to the high permeability fractured schist rock intervening between the pit sump and main stem of Rise and Shine Creek.

8. This dewatering would induce an estimated maximum of 17 L/s of lost creek flow from Rise and Shine Creek. However, mitigation of such creek water loss by using upstream diversion channels around the Srex pit are planned.

9. Rise and Shine Creek would be impinged by the edge of the RAS pit engulfing the creek bed during the development of surface mining. Planning to avoid the capture of creek flow envisages the installation of a diversion culvert to carry creek flow along the pit wall and into the downstream creek bed outside of the pit. All except flood flows would thus be conveyed to the lower Rise and Shine Creek catchment ensuring equivalent hydrological conditions to the Bendigo Creek catchment. Flood flows that exceeded the culvert discharge capacity would cascade down the pit wall for collection in the sump (or the pit lake following the operational phase).

10. Aside from the operational phase, the active closure period would entail the restoration and progressive rehabilitation of former mining surfaces. Active and eventually passive water treatment would be deployed to moderate the composition of higher strength mine-impacted water streams before they entered either creek, and ultimately downstream groundwater. Furthermore, a large delay to the restoration of the previous saturation level centred on the RAS pit lake would isolate that 70 hectare zone hydrologically from the Shepherds Creek until drainage initiated *via* the underground portal.

11. The post closure phase of the BOGMP would include the re-establishment of less artificial surface water drainage. The elements of post closure phase drainage that differ significantly from the pre-mining hydrology, include the following:
    a. The RAS pit and subterranean drainage *via* the residual underground passages,
    b. The flattened profile and porous substrates of the former TSF,
    c. The rolling profile and porous substrates of the former ELFs, and
    d. The culvert conveying Rise and Shine Creek around the RAS pit wall.

12. These departures from pre-mining hydrological conditions are projected to increase the flow rates of Shepherds Creek for the mean (+37%), median (+47%), and Mean Annual Low Flow (+88%) creek flow rates, and of Rise and Shine Creek for the mean (+35%), median (+43%), and MALF (+82%). These changes in runoff characteristic are attributed to the emplacement of flatter, more porous / permeable

substrates of the former mine waste management areas in both catchments, plus the continued pit lakes with subterranean drainage of the former RAS and SRX mining zones.

13. The Mine Waste Management report on source terms and site water balance (Mine Waste Management, 2025a) and (Mine Waste Management, 2025b) outline that the TSF, ELFs and parts of the former mining surfaces would leach dissolved metals, but particularly solutes of sulphate and nitrogen. The zones of leachate release are predictable, such as the Shepherds Seepage Collection Sump at the terminus of seeps, toe drains and stormwater pipelines, allowing the leachate to be collected and diverted into active treatment or passive treatment systems for the reduction and amelioration of solute concentrations. The post closure phase transportation of solutes would include dilution in the surface water network followed by dispersion within the groundwater system after infiltration through the creek bed.

14. The progressive increase in the net liberation of solutes such as sulphate and nitrogen (from rock weathering and blasting agents, respectively) from emplaced mining wastes in creek water would accumulate in the alluvial / outwash groundwater systems in their respective catchments. Substantial minimisation and remediation of the mass loads of these solutes, particularly water treatment, would prevent as much dissolved contaminants entering the surface water system by the mining waste management proposals (Mine Waste Management, 2025a).

15. The make-up water requirement for the volumetrically significant water uses such as ore processing would be underpinned by the operation of a 110 litre per second capacity bore field and pipeline tapping the Bendigo Aquifer.

16. Pumping operation by the bore field is projected to cause a loss of flow for the Clutha River / Mata Au in the region of 64% of the maximum annual pumping, i.e., 70.4 litres per second. Due to the high mean flow rate of the river at 271,100 litres per second at Bendigo, the loss of river flow would be inconsequential and/or *de minimis*. The river is not currently allocated but the calculated maximum groundwater depletion effect would also fit within proposed surface water allocation limits proposed for the Clutha River / Mata Au.

17. Mitigation of the above effects are integral to the mine and hydro-environmental designs, as summarised herewith –
    a. The scheduling of mining stages, especially during operations to optimise the ability to mitigate potential effects,
    b. The use of cemented tailings to replace the material in underground stope voids, avoid the potential for goaf collapse and attendant effects of subsidence and propagation of fracture permeability enhancement that would have otherwise caused flow loss to Shepherds Creek as it passed over the underground workings,
    c. The steps taken to design waste and water management systems such as the Shepherds Silt Pond, TSF and ELFs with the attendant ability to maximise the reuse of and water use substitution,
    d. Water treatment systems [see (Mine Waste Management, 2025b)] to manage the release concentrations of former mine site drainage nodes as water reuse tapers off in the active closure phase,
    e. Passive water treatment systems [see (Mine Waste Management, 2025b)] developed and maintained to take over the role of attenuating any remaining contaminant concentrations in

runoff from the former mine site as the land surfaces are rehabilitated and revert in the future post closure period, and

f. Water use conservation through operational reuse of mine-impacted water, including storage in the TSF, would minimise the requirement to take groundwater with depleting effects on the Clutha River / Mata Au.

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